ENGINEERING

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Pay and the Position of Responsibility

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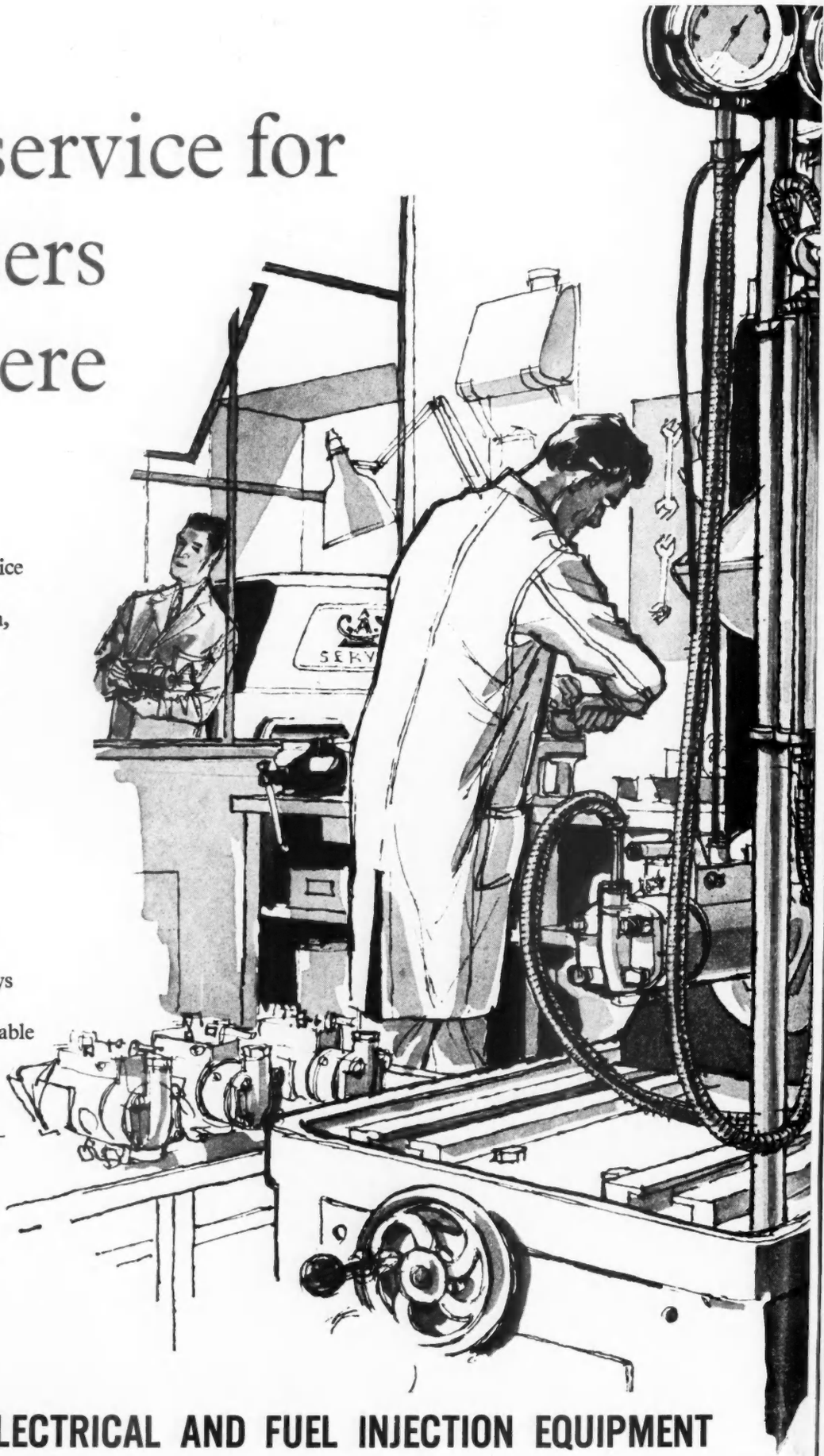

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AP 207

ENGINEERING Impact

Applying the Craft of Hovering

EVERY facet of the engineering industries seems determined to cash in on Mr. Christopher Cockerell's hovercraft principle.

Now the British Iron and Steel Research Association have developed what they term the "hover pulley." Described in the Design section on page 826 of this issue, it is a device which enables thin steel-strip to be guided through mill processing lines on cushions of gas or liquid, with many ensuing benefits.

Now being further developed by BISRA and by Head Wrightson for commercial exploitation, it is an example of inverted thinking. User firms producing thin strip asked BISRA to find new methods for control of tensioning —thin strip is liable to breakages unless tensions can be kept low.

Instead of adding more elaborate control gear to existing machines or introducing improvements to established methods, BISRA appreciated the need for a completely new approach to the problem, within two years producing what appears to be a very promising design. Practicability has been demonstrated on a large-scale laboratory plant.

So often research workers and designers are so dyed in the traditions of their own industry that they cannot view new problems with anything more than improvements on traditional methods. Equally often, when a new idea is born it frequently dies for lack of commercial confidence in it or the courage to introduce something different.

In this instance, neither BISRA nor Head Wrightson, in their respective roles have fallen down on the job. Engineering can do with more of this kind of untramelled thinking.

Management's Effect on Research Efficiency

ONE of the most acute problems currently facing British industries is the shortage of qualified scientists and engineers. In the long term the problem can be solved by programmes of expansion in universities and technical colleges but, meantime, greater effort could be made to increase the effectiveness of the manpower available.

This is one of the salient issues raised in the *Report of the Committee for the Management and Control of Scientific Manpower*, published last week by HMSO (7*s* 0*d*). The terms of reference of this Committee, which was originally under the chairmanship of the late Sir Claude Gibb and afterwards of Sir Solly Zuckerman, restricted their investigations to research and development work wholly financed by the Government. In this context, their deliberations on scientific manpower refer almost entirely to the Scientific Civil Service. But this does not mean that the Committee's recommendations have little bearing on civil research.

The committee make the observation that, unlike men in administrative employment, most research workers make their major contributions (to scientific discovery) during the early stages of their careers. This fact should be appropriately recognized in terms of pay and promotion, say the Committee.

Stimulus is vital to the successful research worker—lack of it can lower his effectiveness by a considerable factor. In this context, the report criticizes Government research management for "insufficient movement of research staff between establishments or, indeed, from one line of research to another."

Considerable emphasis is placed on staff management in the report, and the potentialities for improved efficiency in this direction are summed up in the statement: "... we are bound to add that the more we have learnt, the stronger has our impression grown that management at all levels has not faced up to some of the problems we have encountered, or, at least, has not exploited existing recruitment and management arrangements fully in order to improve the present situation."

Ideas into Reality for Nuclear Ship

NOBODY would deny that research is necessary, but it becomes prodigal if it is continued for its own sake, delaying production plans.

Such escapism can be suspect of the tactics of stalling—invoked, perhaps, because of anxiety on the score of premature production or expenditure. But when there is a strong feeling that existing knowledge justifies the building of an urgently needed product, the question arises whether hesitation of this kind is not only miscalculated but, indeed, harmful.

This situation would seem to affect the Government's policy apropos the development of a merchant ship having nuclear propulsion. In May, 1959, a group of companies put forward design studies for ship reactor systems, and these aroused much official interest. A technical sub-committee, Sub-Numarcom (now TechNumarcom) decided that water cooled reactors and perhaps an organic moderated reactor could be installed without a shore prototype. Tenders were invited, and were sent in during July, 1960. After much uncertainty and discouragement, Mr. Marples, Minister of Transport, announced on 8 November last that, though no nuclear reactor was to be ordered, the UKAEA, with the help of industry, were to carry out research and development of marine reactors.

Captain H. F. Atkins, of Vickers Nuclear Engineering Limited, is one of those who protest strongly against this trend of getting nothing practical done. The further paper research and pilot scale plants which seem to be in the offing will be of little avail in a world that sees Russia and the United States with nuclear ships in operation or building, and Germany with a boiling water reactor, appropriate for a tanker, already working. Captain Atkins believes that the UK should develop a small steam cooled heavy water moderated reactor and simultaneously install a seagoing prototype in a fast fleet tanker—this programme being drawn up at once by the Ministry of Transport and the Admiralty, under the Minister for Science; and that £20 million should be voted for this now. Thus the position as compared with progress elsewhere might be restored, and would very probably arouse NATO interest.

There is an art in knowing when to stop some kinds of research.

Matching Port Works to Shipping Trends

THOUGH it may be true that no two ports are the same, yet it is equally true that many have problems in common. Lest the point should be forgotten, it is made abundantly clear by the evidence prepared by the Federation of British Industries for presentation to the Rochdale Committee and published in a booklet, *Major Ports of Great Britain* (3*s* 6*d*).

As with the London Chamber of Commerce in their Report (ENGNG., 18 Aug. '61, p. 193), suggestions are put forward by the FBI for improvements by introducing shift working; by increased development (calling on Government funds if necessary); and above all by better cooperation between users, authorities and workers.

Access to the port is criticized, that at London, Liverpool and Middlesbrough coming in for particular condemnation. The cross-river facilities at Hull and the Mersey are reported as being bad, but it should be remembered that large span suspension bridges are planned at both these points, their construction waiting only on Ministry of Transport approval. New works at Tilbury are applauded, but the FBI warn that adequate road access must be provided not only at the port itself, but along the whole route from London with possibly a through route to the West. Given entry to the Common Market, cross-Channel traffic will increase, and any port developments in the south ought to take this into account.

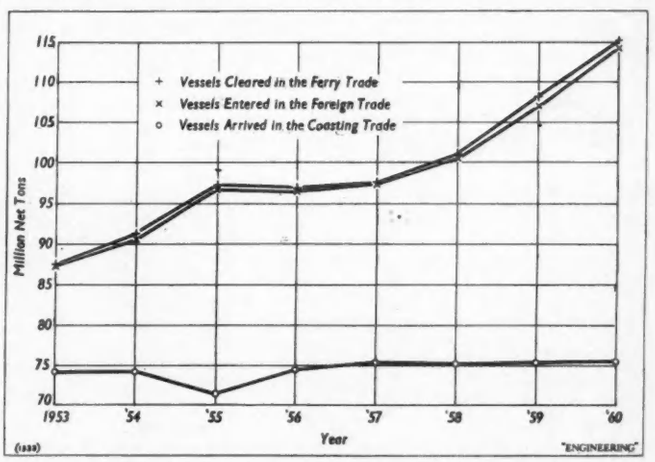
From the replies received to the FBI's inquiries, it is clear that the great majority of ship movements are made from the Thames, Southampton Water, Bristol Channel (five ports), Mersey (two ports), Glasgow, Leith, Grangemouth, and five ports in the Tyne and Humber areas. The FBI do not seem to consider that there would be any gain by general amalgamation of port authorities—indeed they say that some are already unwieldy—but they do believe that the Public Trust system of ownership should be extended, while retaining local autonomy.

Figures from the *Abstract of Statics* show that though coastal trade has not increased during the last few years, external shipping has. The coastal shippers have been very disturbed recently at the competition now being offered to their trade by the railways, who are accused of undercutting. If this trend in shipping continues, it would seem best to concentrate on the larger ports for development (particularly to improve facilities for deeper draught vessels). The smaller nearby ports could then be incorporated into satellite groups centred on a large port, or development of them left until much later.

Pay Pauses, Mergers and Continental Competition

FEAR of the Common Market is not one-sided. The approaching competition from British industries is being viewed with respect, and even concern, in many sectors on the Continent. The prospect of the merger between Imperial Chemical Industries and Courtaulds does nothing to relieve the apprehension.

Price, as always, is going to be the controlling factor in trade. Price follows immediately from internal efficiency of the manufacturing concern. Increased efficiency was the prime reason put forward by Mr. Paul Chambers, the ICI chairman, for the merger. Objections that the combined company would have a monopoly of man-made fibres was still-born on two scores. First, there has always been a degree of cooperation between the two companies—witness in particular, their joint interest in British Nylon Spinners. Secondly, what is a monopoly within the United Kingdom will not be a monopoly in the Common Market.



Pointer to port construction in the United Kingdom.

As was shown last week in these columns, Britain's export prices have kept comparatively stable for the last two years; by contrast, those of Germany and France have risen and, over these two years, Britain's exports of manufactured goods to the Six have increased by a third. Whatever criticisms there may have been within Britain about the pay pause, there is little doubt that it is the envy of the Continental countries who have seen their own wage bills continue to spiral upwards.

Guiding Thin Strip on Cushions of Air

BISRA have developed a new device, the Hover Pulley, which enables thin steel strip to be guided through mill processing lines on cushions of gas or liquid, so avoiding the use of guide rolls.

Food packaging, once the province of the tin can, has been invaded by the paper and plastics industries and, to a lesser extent so far, by aluminium can making. Conscious of this challenge, tin plate manufacturers are out to reduce cost and weight of cans for food and drink containers by reducing the thickness to about half that used at present.

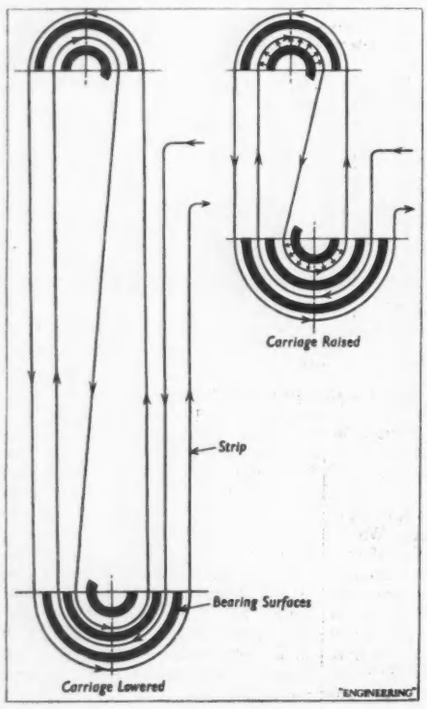
This calls for plate as thin as 0·006 in, which, although strong enough for its purpose, needs very careful handling and low tensions during manufacture to avoid tearing or damaging its surfaces. (Last week on page 812, we reported details of the new electrolytic tin plating plant at Richard Thomas and Baldwins which can handle strip down to the thickness mentioned.)

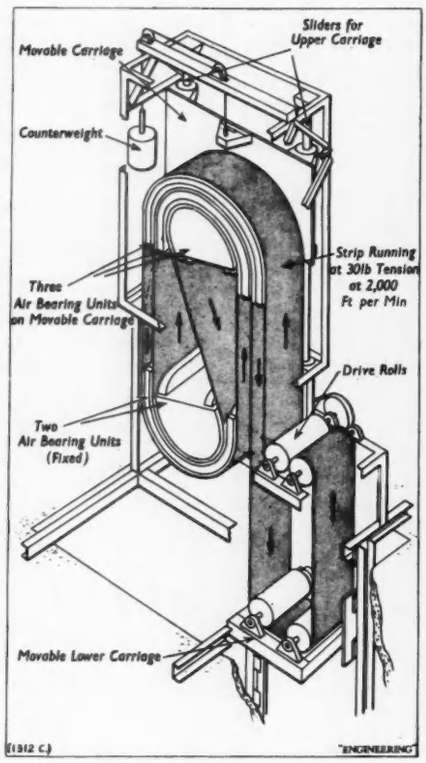
A conventional electrolytic tinplating line may use anything from 70 to 150 guide rolls for guiding the strip through its tortuous path. A high proportion of these rolls must be driven to avoid excessive tension in the strip. Keeping in mind friction in bearings, inertia of rollers and sufficient tension to keep the strip on the rollers, the total tension on the strip is considerable.

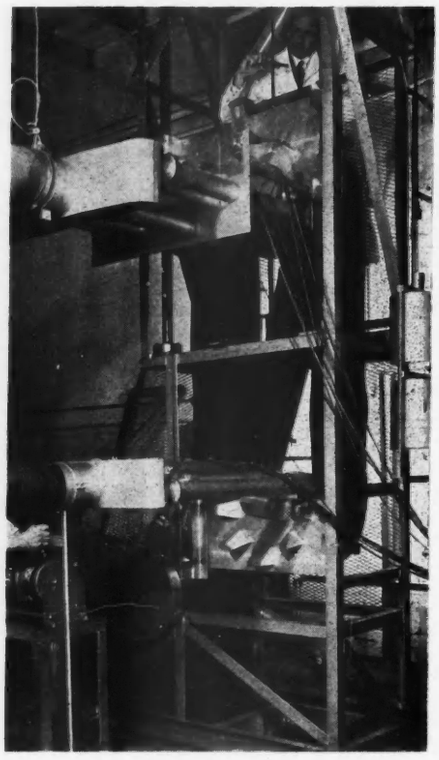
Completely New Approach

The British Iron and Steel Research Association were asked if they could find new methods of tension control. BISRA felt there was a need for a completely fresh approach and explored other possibilities.

Fluid cushioning was found by calculation and laboratory experiments to be technically feasible and economical as a means of supporting light gauge strip. They have now developed an arrangement known as a Hover Pulley (Fig. 5), in which the conventional series of rollers is replaced by a series of guide surfaces having a cushion of fluid (gas or liquid) between them and the moving strip.







Figs. 1 and 2 The labyrinth looping tower at BISRA's Battersea laboratories. It has been running for the past six months using strip 12 in wide by 0·008 in thick supported on a cushion of air.

The cushion is formed by blowing a quantity of low pressure gas or liquid between the strip and the guide surface. In principle the method is similar to that used in the hovercraft in that a pressure rise occurs within the area bounded by annular (slot) jets, if the jets are in close proximity to a boundary surface.

The laboratory rig (Figs. 1 and 2) built by BISRA supplies air for the cushion at between 20 and 30 in wg. Strip 12 in wide by 0·008 in thick has been used on the tests and the gap between the strip and the bearing surface is in the order of 1/10 in, although it has been as low as 1/20 in. The jets are 10 in apart and about 1/10 in wide. It appears that as long as the edge of the strip overlaps the peripheral slits of the jet, sufficient lift is obtained. The rig normally runs on a tension of 30 lb though it has been up to 90 lb.

BISRA's rig is a novel design of looping towers where the strip comes in at a variable speed and leaves at a constant speed. The loop serves as a store which has a variable capacity, adjusted by raising or lowering the bottom carriage.

As can be seen from a comparison of Figs. 3 and 4, the air bearing or labyrinth looping tower not only has the advantage over the conventional serpentine arrangement of low tension and no rubbing of the strip surfaces, but also of compactness for instead of several loops in series they are carried concentrically. A similar arrangement can be used for the support and guidance strip in a liquid processing tank, whereby a given length of strip can be accommodated in a tank of smaller volume than that required for a conventional arrangement.

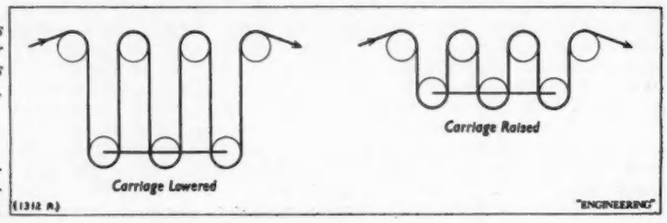
Facts and Figures

Some typical experimental figures, given by BISRA as an example, show that a single semi-cylindrical air-cushioned bearing of 2 ft dia, to support 36 in wide, small-gauge tinplate under a tension of 150 lb requires an air supply of 980 cu. ft per min at a pressure of 27 in wg. This is equivalent to a fan of about 9 bhp, allowing for duct losses and fan efficiency. An important design parameter which has been borne in mind has been to keep air pressures required within the capabilities of a fan which is relatively cheap to install and maintain as compared with a compressor. On BISRA's laboratory rig, the two main ducts supply the compressed air to subsidiary ducts through which the air is passed to the upper and lower units of multiple bearing surfaces.

It is only two years since the idea of the Hover Pulley was conceived and BISRA's rig has been operating at their Battersea laboratory for the past six months. This rapid progress has been due to close cooperation between BISRA, acting under strong stimulus from a user firm,

Fig. 3 (left) BISRA's labyrinth looping tower using Hover Pulleys is much more compact.

Fig. 4 (right) Conventional serpentine arrangement for a looping tower.



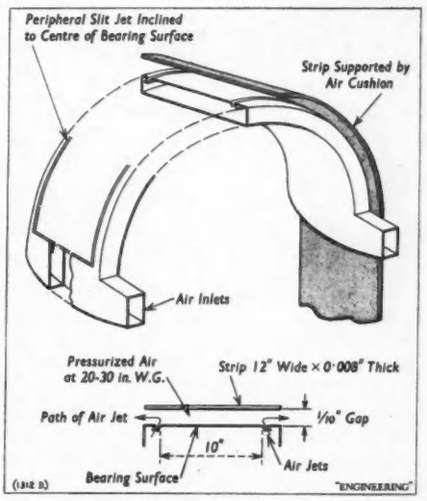
and Head Wrightson, who themselves have an exclusive licence to manufacture such bearings.

The research and development department of Head Wrightson have constructed a full-scale pilot rig incorporating four air bearings 12 to 36 in dia, and an 18 in dia liquid bearing which can be run partly or fully submerged. The rig operates with a closed loop of strip 32 in wide by 150 ft long and strip speeds can be varied up to 2,000 ft per min. Development work is proceeding to improve the performance of the bearings and to study problems peculiar to the types of processing line in which the bearings may be installed. Five different geometries of bearing surface are in the rig and the bearings are made of pvc.

Preliminary studies have been made of strip cleaning and chemical lines, and also of continuous annealing lines as well as further studies still in progress on electrolytic tinning lines.

Fluid bearings, say Head Wrightson, will be cheaper than conventional rolls for most applications and will need little maintenance. For use where the strip is submerged, liquid bearings should offer a very attractive alternative to the costly sink roll which is often a major source of trouble to maintenance staff.

Fig. 5 The Hover Pulley is a semi-circular air bearing unit over which the strip runs supported by a cushion of low pressure gas or liquid.



Advantages of the Hover Pulley can be summarized as follows: (1) strip surfaces cannot be damaged; (2) guide rolls are avoided; (3) line tensions can be kept low; (4) there are no tracking problems; (5) there is no apparent limitation on strip speed; (6) more compact design is possible with concentric pulleys than with a conventional serpentine arrangement of loops.

British Iron and Steel Research Association Limited, 11 Park Lane, London W1.
The Head, Wrightson Machine Company Limited, Commercial Street, Middlesbrough, Yorkshire.

Flight-Deck for SC5 Freighter Meets Dual Requirements

Flight-deck layout for the Short SC5 Belfast strategic freighter has received the approval of the Air Registration Board and the Ministry of Aviation, and RAF Transport Command who will operate the aircraft.

Short Brothers and Harland, the builders, say that with such joint approval the Belfast becomes the first aircraft to meet—at one and the same time and without modifications—the requirements of both civil and military authorities in this respect. What the approval means, in effect, is that the SC5's flight deck could be incorporated in a civil version of the freighter without the time-consuming and expensive alterations normally involved in producing a commercial variant of a military aircraft.

While the requirements of the two bodies concerned vary in many respects, it was decided at an early stage to aim for a flight deck capable of fulfilling both military and civil roles.

One important point upon which military and civil specifications differ concerns the limits of the pilot's field of view in various directions. After an exhaustive analysis involving the size, shape and position of windows, and the position of the pilot relative to the window in both vertical and horizontal planes, Shorts' engineers produced a design satisfactory to both authorities. Such things as the location of individual instruments and controls, methods of entry to the crew seats, head room, lighting and colour schemes also had to be borne in mind as dual requirements.

Over the long stages for which the Belfast is destined to fly, minimum crew fatigue is a necessity. In addition to having a cockpit layout designed to produce maximum working efficiency, the aircraft is fitted with the latest navigational and flying aids and an automatic landing system suitable for use on a civil airliner. It is the Autoland system, based on techniques established by the Ministry of Aviation's Blind Landing Experimental Unit and now being developed by Smiths Aviation Division in conjunction with Standard Telephones and Murphy Radio.

Another of the flying aids is the device known as PEEP (Pilot's Electronic Eye-level Presentation system). It is fitted at the captain's station and employs a small transparent screen situated between his eyes and the windscreen. Information required by the captain, such as altitude and indicated air speed, is projected on to the screen where he can assimilate it without diverting his attention from outside.

"System Control" principles have been applied to simplify the flight engineer's work. In place of the conventional closely packed array of indicators and controls, he has six separate panels covering de-icing, autolanding, engines and air conditioning, fuel, electrical and miscellaneous systems. Each group is laid out in diagrammatic form in such a way that should a warning light come on, the location of the fault is instantly apparent to the engineer. This enables him to take action to remedy any fault without having to deduce where it lies.

The SC5, now being built at the Queen's Island factory in Belfast, is scheduled to fly at the end of 1962.

Short Brothers and Harland Limited, Seaplane Works, Queen's Island, Belfast.

Pantograph Test Unit for Improving Current Collection

To help improve overhead electric current collection on the Eastern Region of British Railways, the research organization of British Insulated Callender's Cables have cooperated with the region in developing a new pantograph test unit.

As one of the principal contractors for the BTC's modernization plan, the BICC Group were responsible for the high voltage ac overhead electrification equipment on all the Eastern Region lines included in the plan. The new test unit is capable of travelling at speeds up to 100 mph.

Capable of travelling at speeds up to 100 mph, this pantograph test unit for the Eastern Region of British Railways, will be used for improving overhead current collection.

It comprises an instrumented coach, fitted with two pantographs, and generator coach which provides the electrical power for the instruments, lighting and heating. An electrically driven air compressor in the generator coach provides the air supply for raising the pantographs. Converted from a normal passenger coach, the test coach has a central observation dome and flat roofs at each end for the fitment of Stone Faiveley type AMBR pantographs.

Most of the instruments in the test coach are contained in a panel 12 ft long by 6 ft high. The panel is mounted below a pantograph which is earthed to the coach and is designated the "dead" pantograph. The dead pantograph is used during tests when the overhead line is earthed and the test unit is being hauled by a diesel locomotive. At the opposite end of the coach is a high voltage enclosure which is situated below the "live" pantograph insulated for 25 kV, which is used during tests with the overhead line live and with a diesel or electric locomotive hauling the unit. Arrangements have been made so that the electric locomotive can draw its power from the live pantograph on the test coach so that the overhead equipment is not disturbed mechanically other than by the measuring pantograph.

Quantities which can be measured and recorded are: pantograph height, acceleration, contact loss, contact pressure (dead pantograph only), locomotive current (live pantograph only), and train speed. In addition, track and timing marks can be inserted on all recordings.

Pantograph height is measured directly by a potentiometer 7 ft long, driven by a lightweight glass-fibre tube attached to the pantograph head. Strain gauge accelerometers attached to the height gauges measure the pantograph head accelerations. Contact pressure is measured by two strain gauge ring dynamometers fitted into the pantograph head, one at each side, the outputs being added to give the total force on the head.

When running with the overhead line live, the line voltage is measured by an instrument transformer and displayed on a meter and recorded so that loss of electrical contact can be easily seen.

British Insulated Callender's Cables, 21 Bloomsbury Street, London WC1.

Plain Words

By Capricorn

WHEN I think of the suffering that is inflicted on engineering plant, equipment, vehicles—machines of one sort or another—by unthinking users, I am moved to propose a Society for the Protection of Machinery. When babies are hurt we know it because they cry. Dogs bite, cats scratch, trade unionists go on strike, electors give their votes to another candidate, shoppers go to another shop, and our own bodies command a whole orchestra of signals, from headaches to groans of pain. But machines —poor things—are more dumb than our dumb friends.

To a sensitive ear, of course, the slightest variation in engine noise is as eloquent as the whimper of the baby to its mother. A friend of mine has this subtle machine-sense developed to a high degree. In fact, his wife told me over Christmas that he was quite indifferent to his own minor ailments, " But if there's a noise in an engine," she said, " that's serious !"

In stark contrast to the solicitude of this engineer is the behaviour of those unreasonable optimists who just carry on driving a car when it develops an ominous knock, hoping that in some mysterious way it will cure itself. They have planned to reach auntie at Little Bumblethorpe in time for tea, and they are going to do it, come hell or high water, or big-ends through crankcases. Little red lights glowing on the dashboard are put out of mind as unpleasant reminders of the tiresome, it-can't-happen-to-me incidents.

These numerous devices which warn the user—the red light on the dashboard is typical—are, of course, supposed to tell us when a machine is beginning to suffer. They can tell us that the oil pressure is low, or that there is no oil at all, or that the engine is too hot, or that the hand brake is still on—or, in " big " engineering, that unless someone does something about it quickly, the breakers will come out or the plant will go up. But these warning devices are themselves liable to let you down just at the moment when they ought to be signalling.

It was no great surprise, then, to hear that in the United States their diesel electric locomotives are being stripped of some of the relays which protect the electrical equipment. It has even been found that the performance and the dependability of the locomotives has since improved. Perhaps this will be a lesson to the Americans, who are over-fond of gadgets on their equipment (perhaps it is the salesmen who dictate policy here).

There is only one type of warning device which I would like to see developed. In the anticlimax after Christmas, in the sobering days of New Year resolutions, will someone please develop a tiny meter for the breast-pocket which will tell me when I am approaching a consumption of alcohol which will produce a hangover the following day.

Letters to the Editor

Engineering a Registered Profession?

SIR, For many years I have been advocating closer integration in the engineering profession and more common teaching of fundamentals before specialization.

These ideas were often greeted with scorn and derision, but now that they have been made respectable by many eminent engineers (including Presidents of institutions) may I stick my neck out still further and advocate proper registration of engineers?

I am sick of reading in the press that the " Engineers " have made a wage claim or that the " Engineers " are going to strike! Why can we not be made a respectable profession like, for instance, doctors, solicitors, dental surgeons or veterinary surgeons, so that only someone who is properly qualified can call himself an engineer?

I am usually told that registering engineers would let in a lot of unqualified people, but other professions have overcome the difficulty. For example, when the dental profession organized itself in this way a lot of unqualified practitioners were admitted but, and this is the important thing, from that day on all dental surgeons had to be properly qualified, and the unqualified and the " quacks " were extinguished for ever.

What objections are there to our following the examples of other professions and other countries? If there are reasoned objections let them be stated, if not let us start to set our house in order and let the Presidents of the chartered institutions make the first move.

Yours faithfully,
J. C. TURNBULL.

Great Ayton,
Yorkshire.
18 December, 1961.

Statically Indeterminate Structural Analysis

SIR, Without wishing to enter into correspondence about teaching methods, I suppose that, as the reviewer, I should reply to the statements made by your correspondents: Mr. J. W. Fortey (ENGNG., 10 Nov. '61, p. 600) and Mr. J. H. Swannell (17 Nov. '61, p. 638).

Referring to Mr. Fortey's comments, the intention of the statement in the review about Castigliano was meant, of course, to include illustrations and examples, not only the theorems alone. The advantages and dis-advantages of various approaches or methods are a matter of opinion, but a textbook of the title in question should not, in my view, be so unbalanced in the methods chosen. The implied comparison is, as I understand it, factual when bachelor degrees are considered, and since one of the reviewer's jobs is to see whether the book has been successful in its purpose the comparison was inevitable.

A number of Mr. Swannell's comments are puzzling to me. If he has taught structural analysis by both methods I do not see why he has difficulty with the integral which he quotes. This is a theorem of no great sophistication and I am obliged to Mr. P. E. Montagnon, whose letter is printed here, for providing a sketch and helpful amplification.

I do not understand Mr. Swannell's reference to " proper " mathematics and would be loth to think that engineers should be able to understand and use only, presumably, " improper " mathematics. Mr. Swannell may be assured that, as a practising engineer, I am aware as to what has, and has not, to do with the profession of engineering.

Dealing with both letters generally, clearly the views of those engaged permanently in teaching must be respected. But the question of approach is very much one of opinion. While my own experience of teaching structures to final-year students is limited to some five years part-time, I am sure both the correspondents will agree that the opinion of engineers engaged in practice is equally to be respected. This is so not only because they can themselves draw on their own experiences as students and engineers, but also—as in this case—because they have the advantage of watching closely the development of young graduates who are engaged by them.

On this basis there is no doubt in my mind as to which of the approaches results in a better standard of graduates.

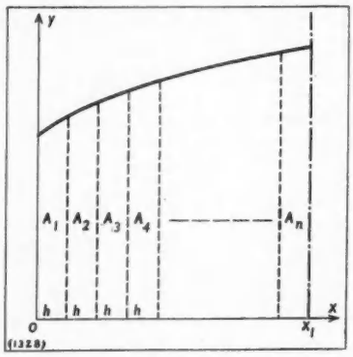
Yours faithfully,
A. GOLDSTEIN.

R. Travers Morgan and Partners,
London EC4.
13 December, 1961.

SIR, Mr. J. H. Swannell asks (ENGNG., 17 Nov. '61, p. 638), for a sketch to clarify the statement

$$\int_0^{x_1}\int_0^{x}\frac{M}{EI}\,dx\,dx=\int_0^{x_1}(x_1-x)\,\frac{M}{EI}\,dx$$

One way of doing this is to draw the graph of M/EI and to consider the moment of the area



around the line parallel to the y-axis through x_1. This moment is, by definition, equal to the right-hand side of the above equation which by considering each of the little areas A_1 A_2 A_3 etc., can be written as the limit of $nA_1 + (n-1)A_2 + (n-2)A_3 + \ldots$ multiplied by the appropriate base length h. This can be rewritten as $A_1 + (A_1 + A_2) + (A_1 + A_2 + A_3) + \ldots$ also multiplied by the base length. In the limit this is equal to the left-hand side of the original equation.

Yours faithfully,
P. E. MONTAGNON.

Egham, Surrey.
4 December, 1961.

Events in Advance

Management Personnel Go into Conference

A FURTHER one-day course for education and training officers and personnel managers is being arranged under the auspices of the British Association for Commercial and Industrial Education and will take place at the Federation of British Industries, 21 Tothill Street, London SW1, on 10 January next.

The conference will be on the general theme of " Background to Operator Training," and is designed to provide participants with an understanding of the techniques used in the training of a wide range of personnel. It will also cover such aspects as the identification of training needs and the economics of installing a scheme of operator training.

Mr. C. E. Brooks, B.Sc., training manager of Personnel Administration Limited, with the assistance of a number of training officers now engaged in organizing operator-training programmes, has been appointed to conduct the conference. Mr. Brooks himself has spent twelve years as a consultant and has had considerable experience in a variety of industries engaged on

production, personnel and training problems. Overseas, he has spent two years in the United States organizing schemes of this character and is currently working in France, Germany and Holland.

Opening at 9.30 a.m., the first morning session will be devoted to a consideration of " objectives and principles." At the second morning session, a panel of training officers will describe applications of operator training in their own factories and will provide particulars of methods adopted and their results.

There will be two afternoon sessions, the first of which will be devoted to the organization of operator training. The final session of the course will take the form of an open forum which is expected to include the consideration of individual problems and difficulties.

A fee of four guineas will be payable by BACIE members attending the course; the fee for non-members being five guineas. Application forms and additional information can be obtained from the course secretary, British Association for Commercial and Industrial Education, 26a Buckingham Palace Road, London SW1, or by telephoning TATe Gallery 4985.

Meetings and Papers

The address and telephone number of the headquarters of each institution are given at the end of this list. Meetings in the headquarters town are held there unless otherwise stated.

Aslib

LONDON
" Satisfying a Demand or Creating a Market?" by H. R. Heap. Thurs., 11 Jan., 6 p.m.

Association of Supervising Electrical Engineers

LONDON
" Static Switching and Control Systems," by B. A. W. Midgley. Central London Branch. White Hall Hotel, Bloomsbury Square, WC1. Mon., 8 Jan., 7.15 p.m.

British Institution of Radio Engineers

LONDON
" Effect of Electro-Magnetic Radiation on Living Tissues "; Discussion, to be opened by Dr. R. A. Weale, L. Banks and L. Bounds. Joint meeting of the Radar and Medical Electronics Groups. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 10 Jan., 6 p.m.

Diesel Engineers and Users Association

LONDON
" Reconditioning High-Speed Automotive Diesel Engines," by J. W. Wicks. Institute of Marine Engineers, 76 Mark Lane, EC3. Thurs., 18 Jan., 2.30 p.m.

Engineers' Guild

CARDIFF
Luncheon Meeting. South Wales and Monmouthshire Branch. Globe Hotel, Cardiff. Wed., 10 Jan., 12.30 p.m.

Illuminating Engineering Society

LONDON
" Lighting for Inspection," by H. E. Bellchambers and S. M. Phillipson. Federation of British Industries, 21 Tothill Street, Westminster, SW1. Mon., 8 Jan., 6 p.m.
MANCHESTER
" Stage Lighting for Schools," by R. A. Hounslow. Manchester Centre. Offices of the North Western Electricity Board, Town Hall Extension, Manchester 2. Thurs., 11 Jan., 6 p.m.
STOCKTON-ON-TEES
" An Approach to Exterior Lighting," by G. P. Cundall. Newcastle upon Tyne Centre. Vane Arms Hotel, Stockton-on-Tees. Tues., 9 Jan., 6.15 p.m.

Institute of Fuel

GLASGOW
" Use of Fuels Other than Coke in the Blast Furnace," by J. Taylor. Scottish Section. Royal College of Science and Technology, Glasgow. Tues., 16 Jan., 7 p.m.

Institute of Marine Engineers

LONDON
" Residual Thermal Stresses in Compression-Ignition Engines," by A. Dearden. Tues., 9 Jan., 5.30 p.m.
BATH
Annual General Meeting. West of England Section. Smith's Assembly Rooms, Westgate Buildings, Bath. Mon., 8 Jan., 7.30 p.m.
GLASGOW
" Latest Trends in Automatic Boiler Control for the Merchant Fleet," by P. A. Gill. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow C2. Wed., 10 Jan., 7.30 p.m.
LIVERPOOL
" Basic Alternating-Current Switchgear Design," by H. Unwin. Merseyside and North Western Section. Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool. Mon., 8 Jan., 6 p.m.

Institute of Metals

BIRMINGHAM
" Some New Bearing Metals," by P. G. Forrester. Birmingham Local Section. College of Advanced Technology, Gosta Green, Birmingham. Thurs., 11 Jan., 6.30 p.m.
OXFORD
" Selling a Metal: The Technical Aspects of Developing New Outlets," by M. Bridgewater. Oxford Local Section. Cadena Café, Cornmarket Street, Oxford. Tues., 9 Jan., 7.15 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
" Measurements in Engine Development," by B. W. Millington. Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Tues., 9 Jan., 7.30 p.m.
BRISTOL
" Alternating-Current Generating Equipment for Transport Vehicles," by J. A. Cook. Western Centre. Royal Hotel, Bristol. Tues., 9 Jan., 7.15 p.m.
MANCHESTER
" Nuclear Power in Great Britain," by P. Bracegirdle. Manchester Centre. Engineers' Club, Albert Square, Manchester. Mon., 8 Jan., 7.30 p.m.
NOTTINGHAM
" Measures in Engine Development," by B. W. Millington. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., 10 Jan., 7.30 p.m.

Institution of Agricultural Engineers

LONDON
" Rig Testing of Agricultural Machinery," by E. Lang. Tues., 9 Jan., 6.45 p.m.
ABERDEEN
" Force Measurement in Agricultural Engineering," by D. W. Tanner. Scottish Branch. Gordon's Technical College, Schoolhill, Aberdeen. Thurs., 11 Jan., 7.30 p.m.
GLASGOW
" Force Measurements in Agricultural Engineering," by D. W. Tanner. Scottish Branch. West of Scotland Agricultural College, 6 Blythswood Square, Glasgow. Wed., 10 Jan., 7.30 p.m.

Institution of Civil Engineers

LONDON
" Construction Methods and Problems of Tall Buildings "; Discussion, to be introduced by J. D. Bibby. Thurs., 11 Jan., 5.30 p.m.
" Use of the Plastic Theory in the Design of a Fabricating Shop," by Professor Sir John Baker, M. R. Horne and L. G. Johnson. Tues., 16 Jan., 5.30 p.m.

Institution of Electrical Engineers

LONDON
" A Linear Transducer of High Accuracy," by P. C. F. Wolfendale. Measurement and Control Section. Tues., 9 Jan., 5.30 p.m.
" Tests of Three Systems of Bandwidth Compression of Television Signals," by G. F. Newell and W. K. E. Geddes. Electronics and Communications Section. Wed., 10 Jan., 5.30 p.m.
" Fourth Edition of the Regulations for the Electrical Equipment of Ships "; Discussion, to be opened by G. O. Watson. Utilization Section. Thurs., 11 Jan., 5.30 p.m.
ABERDEEN
" Sphere-Caps," by Dr. E. Kuffel. North Scotland Subcentre. Robert Gordon's Technical College, Aberdeen. Fri., 12 Jan., 6 p.m.
BIRMINGHAM
" The Place of Formal Study in the Post-Graduate Training of an Electrical Engineer," by N. N. Hancock and P. L. Taylor. South Midland Centre. James Watt Memorial Institute, Birmingham. Mon., 8 Jan., 6.30 p.m.
DUNDEE
" Sphere-Caps," by Dr. E. Kuffel. North Scotland Subcentre. Electrical Engineering Department, Queen's College, Dundee. Thurs., 11 Jan., 6 p.m.
HULL
Chairman's Address, by W. J. A. Painter. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., 18 Jan., 6.30 p.m.
LIVERPOOL
" Protection of High-Voltage Insulators from Power-Arc Damage," by Dr. A. E. Guile. Mersey and North Wales Centre. Royal Institution, Liverpool. Mon., 15 Jan., 6.30 p.m.
MANCHESTER
" Transmission of Power at High Voltages," by F. J. Lane. North Western Centre. Engineers' Club, Albert Square, Manchester. Tues., 9 Jan., 6.15 p.m.
NEWCASTLE UPON TYNE
" Transmission of Power at High Voltages," by F. J. Lane. North Eastern Centre. Literary and Philosophical Society, Westgate Road, Newcastle upon Tyne. Mon., 15 Jan., 6.15 p.m.

Institution of Heating and Ventilating Engineers

LONDON
" Mechanical Engineering Services in a Modern Hotel," by R. E. Tully. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Thurs., 11 Jan., 6 p.m.
BIRMINGHAM
" Design and Application of Packaged Boilers and Automatic Stokers," by R. D. Northcote. Birmingham Branch. Birmingham Engineering Centre, Stephenson Place, Birmingham. Tues., 9 Jan., 6.30 p.m.
NEWCASTLE UPON TYNE
" Engineering Services at the Western General Hospital, Edinburgh," by M. E. Vincent. North East Coast Branch. Neville Hall, Westgate Road, Newcastle upon Tyne. Tues., 9 Jan., 6.30 p.m.

Institution of Highway Engineers

LEEDS
" Motorway Maintenance," by P. H. Meacock. Yorkshire and Lincolnshire Branch. Griffin Hotel, Leeds. Thurs., 11 Jan., 7 p.m.

Institution of Mechanical Engineers

LONDON
" Small Gas Turbines," by Dr. John H. Weaving. Nominated Lecture. Automobile Division. Tues., 16 Jan., 6 p.m.
GLASGOW
" Development of Water-Lubricated Boiler Feed Pumps," by G. F. Arkless. Scottish Branch. Royal College of Science and Technology, Glasgow. Thurs., 11 Jan., 7.30 p.m.
MANCHESTER
" Hovercraft," by W. A. Fennington. North Western Branch. Engineers' Club, Albert Square, Manchester. Thurs., 11 Jan., 6.45 p.m.
NEWCASTLE UPON TYNE
" An Experimental Study of the Flow Conditions and Pressure Drop of Steam-Water Mixtures at High Pressures in Heated and Unheated Tubes," by R. W. Haywood, G. A. Knights, G. A. Middleton and J. R. S. Thom. North Eastern Branch. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 8 Jan., 6 p.m.

Institution of Mining and Metallurgy

LONDON
" Fineness of Gold in Some Southern Rhodesian Mines," by Dr. H. V. Eales; and " Operation at Bikita Minerals (Private) Ltd., Southern Rhodesia," by Ralph Symons. Geological Society, Burlington House, Piccadilly, W1. Thurs., 18 Jan., 5 p.m.

Institution of Plant Engineers

LONDON
" Development and Operation of Nuclear-Powered Submarines," by Lieut.-Commander G. M. Vahsen, U.S.N. Institute of Marine Engineers, 76 Mark Lane, EC3. Tues., 16 Jan., 7 p.m.
GLASGOW
" Silicons in Engineering Applications," by A. T. Voaden. Glasgow Section. Scottish Building Centre, 425 Sauchiehall Street, Glasgow C2. Thurs., 11 Jan., 7.15 p.m.
MANCHESTER
" Some Unusual Practical Electrical Controls, by J. Fairhurst and S. V. Mussett. Manchester Section. Manchester Literary and Philosophical Society, George Street, Manchester. Tues., 9 Jan., 7.15 p.m.

Institution of Production Engineers

BIRMINGHAM
" Contribution of the Production Engineer to Overall Management," by B. E. Stokes. Birmingham Section. James Watt Memorial Institute, Birmingham. Wed., 17 Jan., 7 p.m.

Institution of Structural Engineers

EDINBURGH
" Structural Application of Tubes and Rectangular Hollow Sections, by G. B. Godfrey. Edinburgh Section. Heriot-Watt College, Edinburgh. Tues., 16 Jan., 6 p.m.

Leeds Metallurgical Society

LEEDS
" Developments in Powder Metallurgy," by L. Harrison University Staff House, University Road, Leeds. Wed., 17 Jan., 6.30 p.m.

Liverpool Engineering Society

LIVERPOOL
" Epicyclic Gearing for Industrial and Marine Use," by P. M. Woodbridge. Joint meeting with local section of the Institute of Marine Engineers. Wed., 10 Jan., 6 p.m.

Radar and Electronics Association

LONDON
" Digital Telemetering," by J. B. Richardson. Royal Society of Arts, John Adam Street, Adelphi, WC2. Thurs., 11 Jan., 7 p.m.

Sheffield Metallurgical Association

SHEFFELD
Annual General Meeting and Address by the Incoming Chairman. Refractories Group. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 16 Jan., 7 p.m.

Society of Instrument Technology

NEWCASTLE UPON TYNE
" Electronic Weighing," by L. F. Cohen. Newcastle Section. Roadway House, Oxford Street, Newcastle upon Tyne. Thurs., 18 Jan., 7 p.m.

Tyne Wear Metallurgical Association

NEWCASTLE UPON TYNE
" Some Aspects of Electrochemical Corrosion," by Dr. T. P. Hoar. Metallurgical Department, King College, Haymarket, Newcastle upon Tyne. Tues., 9 Jan., 6.30 p.m.

Women's Engineering Society

LONDON
" Bluebird Project," by D. Stevens. London Branch. Hope House, 45 Great Peter Street, SW1. Mon., 8 Jan., 7 p.m.

Aslib (Association of Special Libraries and Information Bureaux), 3 Belgrave Square, London SW1. (BELgravia 5050)
Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London WC1. (LANgham 5927)
British Institution of Radio Engineers, 9 Bedford Square, London WC1. (MUSeum 1901)
Diesel Engineers and Users Association, 18 London Street, London EC3. (ROYal 2393)
Engineers' Guild, 201 High Holborn, London WC1. (HOLborn 1057)
Illuminating Engineering Society, 32 Victoria Street, London SW1. (ABBey 5215)
Institute of Fuel, 18 Devonshire Street, Portland Place, London W1. (LANgham 7124)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London EC3. (ROYal 8493)
Institute of Metals, 17 Belgrave Square, London SW1. (BELgravia 3291)
Institute of Road Transport Engineers, 1 Cromwell Place, South Kensington, London SW7. (KENsington 3744)
Institution of Agricultural Engineers, 6 Queen Square, London WC1. (TERminus 0140)
Institution of Civil Engineers, Great George Street, London SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London WC2. (COVent Garden 1871)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London SW1. (SLOane 3158)
Institution of Highway Engineers, 47 Victoria Street, London SW1. (ABBey 3891)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London SW1. (WHItehall 7476)
Institution of Mining and Metallurgy, 44 Portland Place, London W1. (LANgham 3802)
Institution of Plant Engineers, 2 Grosvenor Gardens, London SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London W1. (GROsvenor 5254)
Institution of Structural Engineers, 11 Upper Belgrave Street, London SW1. (SLOane 7128)
Leeds Metallurgical Society. Apply to Dr. P. R. Beeley, The University, Leeds.
Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool 2. (Central 3717)
Radar and Electronics Association, 83 Portland Place, London W1. (LANgham 8183)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865)
Society of Instrument Technology, 20 Queen Anne Street, London W1. (LANgham 4251)
Tyne Wear Metallurgical Association. Apply to Mr. J. K. O'Hanlon, C. A. Parsons and Co., Ltd., Fossway, Newcastle upon Tyne 6.
Women's Engineering Society, 25 Foubert's Place, London W1. (GERrard 5212)

Pay and the Position of Responsibility

Responsibility, payment and individual capacity have been studied by Elliott Jaques. On the basis of his work criteria of promotion and demotion are obtained.

M. Davidmann

Consultant to Social Organisation Limited

A PERSON carries responsibility when he has to seek and choose between alternative possibilities, that is, when he has to make decisions. The making of a decision commits the organization's resources to the extent of the discretion and judgment authorized, in fact, to the extent of the responsibility carried by the person making the decision. Status and payment are closely related to responsibility, that is, they are related largely to the use of discretion and judgment; such factors as title, number of subordinates or formal qualifications possessed are not of much account.

A measure of the responsibility carried by a person is the maximum length of time, called the maximum time-span, during which a decision made on his own initiative commits the resources of the company, that is, during which he is authorized to make his own decisions without direct or indirect review of the decisions made.

PROFESSIONAL REMUNERATION

Jaques[1] has thrown considerable light on just what it is that determines remuneration of professional employees. They are paid according to the responsibility carried and a relation thus should exist between responsibility, measured in terms of time-span, and remuneration. Jaques gives the data but does not correlate it. However, it may be represented, using objective scales, as shown in Fig. 1. It is not really possible to draw a reliable smooth curve through his data, there being a distinct break at a time-span of between 1 month and 1 year.

Jaques did not differentiate between manual and managerial employees. Managerial employees are professional employees. Their ability to judge and decide increases with experience while they remain in the same grade.[2] The manual employee, concerned with low levels of responsibility, once fully trained, does not increase his usefulness in the same way. He is paid the negotiated rate for his grade. And herein lies the difference between them which explains the discontinuity in Jaques' data. The manual employee's rate is fixed at any particular time in accordance with his grade. Should he be able to carry more responsibility then he may, by promotion, advance to a higher grade and be paid at a higher rate, fixed irrespective of age. The professional employee, on the other hand, absorbs and applies experience and the level at which he works increases continually, that is, the responsibility which he carries increases continually, up to a point, and he is paid according to the level at which he is employed. This applies to any one particular grade. His grade is determined by his ability to judge, that is, his ability to carry responsibility, and by the positions open to him.

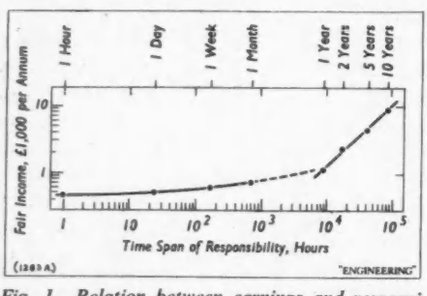


Fig. 1 Relation between earnings and responsibility (Jaques 1955 data).

Remuneration, at any particular time, is determined by the volume and by the level of the work being done. The greater the amount of work done or the hours worked, the greater is the remuneration received by a manual employee who may be placed at one end of an arbitrary scale of responsibility. At the other end, remuneration depends on level of work, which means it depends on the responsibility carried. The factor

$$F = e^{-(X-x_0)^2/b} \quad .. \quad .. \quad (1)$$

indicates[2] how remuneration, and thus how responsibility being carried, varies with age for a person in a particular grade, where X is the age of the individual, x_0 is the age at which remuneration is a maximum for his grade, and b is a constant for each profession.

A measure of comparative responsibility carried is given by career and mean career earnings, for one or more professions, respectively, between grades. For a single profession the y_0 distribution[2] can serve to compare responsibility carried by the varying grades. Here y_0 is the maximum remuneration for each grade.

For the trained manual employee who receives his maximum remuneration from the point of view of responsibility at whatever age he happens to be, the factor F is unity. In between manual and professional employees there is the complete range of employees. The overall scale ranges from manual employees, through professional employees, to those with unearned income.

REMUNERATION AND RESPONSIBILITY

Jaques' data give what was felt to be fair remuneration for responsibility carried. Allowing that at one end of the scale there are manual employees and at the other professional employees, his data may be correlated further, as illustrated by Fig. 2, for professional employees. His data may be represented by the equations:

$$Y_{1954} = 425 + 740R \quad .. \quad (2)$$
$$Y_{1955} = 450 + 830R \quad .. \quad (3)$$

where

Y = remuneration (£ per annum), and
R = responsibility (time-span of) (years).

These may be interpreted by assuming that remuneration consists essentially of a basic minimum, paid when responsibility carried is negligible, plus additional reward in proportion to responsibility carried. The data relate to April of the year.

The basic subsistence remuneration is that given by Jaques for a time-span of one hour and between April, 1954, and April, 1955, those working at that level considered as fair an increase of 6 per cent. The rate of remuneration for responsibility which was considered fair in April, 1954, was £740 pa per year of time-span, and about £830 pa per time-span year in April, 1955, so that an increase of about 12 per cent was considered fair. A judgment of what is fair is based on status, both with respect to one's equals and respect to others.

Basic rates of remuneration for responsibility, that is the rates of £740 pa and £830 pa for April of 1954 and 1955, respectively, per time-span year, may be used to obtain an estimate of "fair" responsibility to be carried by any particular individual, grade or position, utilizing the National Remuneration Scale. Let "B" represent the basic rate of remuneration per time-span unit of responsibility, for example, in units of £ pa per time-span year, noting that the basic rates derived from Jaques' data are estimates of this. Then Y/B is the responsibility carried in terms of time-span and this change of scale converts the National Remuneration Scale[2] into a National Responsibility Scale. y_0/B gives the maximum amount of responsibility carried by any particular individual or grade at age x_0.

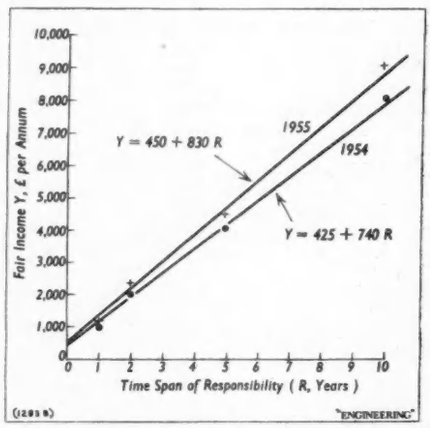


Fig. 2 Correlation of Jaques' data on time-span.

STATUS AND RESPONSIBILITY

One would not expect the responsibility carried by individuals of a given grade and age to vary with time and hence the National Responsibility Scale should remain constant, the sole variable being the remuneration per unit responsibility, that is "B." However, if this is so, then as status is reduced so B must be reduced also. For example, we have seen[2] that the higher grades of chemists receive smaller percentage increases in remuneration than the lower grades so that they are losing status, and if the responsibility carried by them remains unaltered, then they are paid at a rate which is lower than that which they ought to receive had they maintained their position. Hence it would appear that the more successful professional employee's rate of remuneration (that is "B") is being reduced when compared with his less successful colleagues, unless, of course, one could show that the responsibility being carried by them is being reduced proportionately, which, however, appears unlikely. From this point of view also it is seen that incentive to succeed as measured by rate of remuneration per unit of responsibility is being eroded, apart from the actual level of remuneration received. As this process continues, so the professional employee, as he grows older, accepts greater responsibility which is paid for at a lower rate. Jaques' data, however, are not in agreement with the above facts.

Jaques considered that maximum time-span was related to what was felt to be fair payment for the work that was being done, at the general rates then obtaining, and as this relationship appeared to apply irrespective of level or occupation, it thus gave a "differential," that is a status, which was felt to be fair. Time-span, however, is a measure only of responsibility and not of status. The remuneration per time-span unit alters with time, but status changes in accordance with rates of change of remuneration. When remuneration per year of time-span for a professional employee increases more slowly than remuneration of a manual employee, then status is lost. The payment that was felt by individuals to be a fair reward seems to have been, on the whole, an estimate of the increase in remuneration they felt was required to maintain their status relative to their equals (for manual employees), and relative also to manual employees (for professional employees), based on changes felt to have taken place.

Jaques noted that there is a considerable difference between individuals in their ability to carry responsibility, that is, in their time-span capacity and that, in addition, the time-span capacity of an individual varies with age. He analysed the biggest jobs individuals had done at various stages in their career in terms of maximum time-span and obtained time-span versus age curves which are similar to the curves which make up the National Remuneration or Responsibility Scale. But he measured not an individual's capacity to carry responsibility, but the responsibility he carried. Only when the individual is unable to carry greater responsibility are the two the same.

It may be concluded that although Jaques' measure of responsibility is an objective measure, the rate of remuneration per unit of responsibility cannot be evaluated from subjective determinations of what is felt to be fair payment, but from the objective National Remuneration Scales as determined from remuneration surveys.

RESPONSIBILITY AND ABILITY

It is the grade which has to be used to compare positions, titles being no help. An engineer in a small organization may carry the title "chief engineer," whereas in a larger organization the engineer of the same grade and remuneration, age for age, may be a "senior engineer." Indeed, a senior engineer in one organization may thus carry more responsibility and receive correspondingly higher remuneration than the "chief engineer" in another. It is the grade as obtained from the National Remuneration Scale, however, which clearly defines their relative position.

Noting the difference between time-span capacity and responsibility carried as a source of frustration or anxiety, Jaques defines "current time-span capacity" of an individual as his time-span capacity at his current age, and considers that "individuals who work full-time, and who elect to work in industry, will press towards finding work at a level corresponding to their current time-span capacity."

A person who carries responsibility in accordance with his ability to carry it, and whose responsibility varies as his ability to carry it varies, will be content as far as his work is concerned and will not be considered by his manager to be pushing or slacking. If he carries either more or less responsibility he will take steps to decrease or increase it, respectively. He may, for example, press for promotion, change his job, or off-load responsibility on to his manager or on to his colleagues.

MAINTAINING CONTINUITY

Consider now a particular level of position in an industrial organization, such as that of "senior engineer," as illustrated by Fig. 3, for the year 1955/56, it being assumed that responsibility is being paid for at rate of £830 pa per year of time-span. In the particular year being considered, this particular position demands carrying responsibility at a minimum and maximum time-span level of about 1 year 5 months and about 1 year 10 months, respectively, the corresponding remuneration consisting of a salary ranging from a minimum of £1,160 pa to a maximum of £1,500 pa. Individuals of all grades from about G30 upwards may now hold this position, as indicated by Table I.

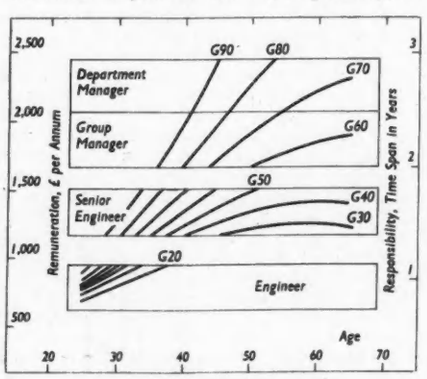


Fig. 3 Salary scale of chemical plant contracting organization (1955/56).

TABLE I *Residence Times for Position of Senior Engineer (1955)*

Grade	Lower Age	Upper Age	Years Position Held
30	44	65*	21
40	40	65*	25
50	37	51	14
60	35	44	9
80	31	37	6
90	28	33	5

* Retiring age

The individual of grade G90 may start in such a position at age 28 at a salary of £1,160 pa, but at age 33 he will take on work at the highest level of responsibility available, then perhaps earning £1,500 pa. From then on he will seek promotion or another position with another organization. The individual of grade G30 would not start in a position such as this until 44 years of age and would stay in such a position until retiring age. However, he would not work at the higher levels of responsibility.

The problem now arises of providing continuity as individuals holding the position come and go, while at the same time enabling the individuals to accept responsibility to the maximum of their ability. In any particular work unit made up of positions at this level, it appears that continuity should be provided by individuals of grade G30 to G50, the various grades being balanced to cover the work that requires to be done. It follows that individuals have to be trained for promotion to this position while they are in the next lower position, the training programme being based on the scale so that they progress smoothly to the next higher position in accordance with their grade. Fig. 3 further illustrates that not too much continuity can be expected where this level of position is held by a number of young, but high grade, individuals. On the other hand Jaques pointed out that expansion, stability or contraction of the work of a work unit depends on the difference between responsibility carried and the ability of its manager to carry it. Hence staffing may be carefully carried out considering these points.

TEST OF POSITION

Individuals have to find their grade and, unless both his executive superior and the person himself agree on the grade of the person, the individual concerned cannot be judged to have been placed correctly. Hence a judgement of grade should not rely on the judgement of only one executive superior unsupported by that of the subordinate and there should not be any hesitation in increasing an individual's grade and the level of the work he does where his ability to carry responsibility has increased. Any failure in this respect may only lead to frustration on the part of the individual and to his leaving the work unit concerned in due course, both of which are detrimental to the performance of the work unit. However, the progress of any professional employee may now be checked by his employer as well as by himself by means of the equations and data given in reference 2.

The same considerations made above on staffing and continuity apply to all levels of position, that is to levels such as those illustrated by Fig. 3.

It is undoubtedly the responsibility of management, as represented by any executive superior, that those employed should be engaged in working at the highest level of responsibility which can be carried by them during any particular period. Hence it would seem to follow that professional employees should be engaged on the basis of grade rather than by title or level of position, and that they should be engaged, under contract, their remuneration being determined by means of equation 33 of reference 2. To maintain the status of the professional employee, I_p, the relevant index for professional employees, should be based on an index of earnings (equation 48 of ref. 2) rather than on an index of wage rates, of manual employees.

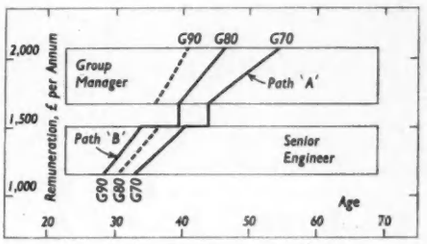


Fig. 4 Promotion and demotion.

In addition, the considerations made here should assist in planning the staffing of work units, to provide necessary replacements and for promotion. Excessive turnover may be caused by too many young and high grade individuals being engaged on tasks which quickly fail to come up to their ability.

PROMOTION AND DEMOTION

Industrial and government work units such as companies or departments have certain scales of remuneration, either known or kept confidential. An example of such a scale is given in Fig. 3. The titles of position are given purely for illustration to indicate the kind of level of each position, for a medium sized industrial (chemical plant contracting) organization. As remuneration varies with responsibility carried, the remuneration of an executive superior should be higher than that of his subordinates, in all cases, and irrespective of the ages or grades concerned, unless difficulties are positively being invited.

It is seen that there may or may not be gaps in remuneration between successive levels of position. When a gap exists, the change from the one level to the next higher is called "promotion" and such changes are illustrated by Fig. 4. An individual may be promoted as soon as he reaches his maximum for the position he holds. But then he is not likely to have been employed at his full capacity, before promotion. He may thus have been frustrated to some considerable extent before promotion or else the possibility exists that he is now tackling work at a level which is beyond his capacity. On the other hand, any movement away and to the right of his grade line is demotion and the individual who remains at the maximum for his position for any length of time is being demoted and, although subsequent advance to the higher level of position may restore his grade (path A), the overall outcome may still be demotion, as illustrated by path B, Fig. 4, the example showing overall demotion from grade G90 to G80. The gap in the scale is thus an effective means of promotion and demotion, where these refer to grade. Should an individual follow path B it is possible that he would be frustrated also in his new position, assuming he was correctly graded initially. The gap further ensures that the remuneration of an individual in the next higher position is higher than that of an individual in the lower position, irrespective of age. Where such a gap is not present, the individual either remains in his grade, or else, remaining at his maximum, is continually demoted with respect to grade.

The author is indebted to the directors of Social Organisation Limited for permission to publish the information contained in this article.

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Human Element

National Council for Economic Development

THE CHANCELLOR of the Exchequer's appointment of Sir Robert Shone as director-general of the projected National Council for Economic Development is likely to help the TUC a step nearer to joining the council. Some of the more reluctant TUC leaders have probably been anxious to know what sort of man would be running the show before committing themselves. Now that the appointment has been made, they can have little quarrel with it—indeed, they are probably relieved that some city gent hasn't been given the job.

Experienced Planner

As the only full-time member of the Iron and Steel Board, Sir Robert has had more practical experience than anyone else of the nearest Britain comes to genuine long-term planning. Looking for some indication of the director-general's personal attitude to planning, Sir Robert's contribution to the conference earlier this year in London on "Economic Planning in France" (ENGNG., 18 Aug. '61, p. 193), is instructive. It is certainly a significant guide to his standing as an economic planner that, with Professor P. de Wolf of the Netherlands, he was one of the two men called upon to sum up the conference.

Appraising the element of social planning in the French four-year plans, Sir Robert said, "the emphasis on educational investment is particularly striking in its implications for meeting both the challenge of the Common Market and the pace of technological development. It is also some evidence of an increasing recognition that investment in education may yield, even in purely economic terms, a better return than investment in industrial equipment." This is encouragingly big thinking—for an economist!

French Example

By and large, though he had reservations about some of the claims made for French planning, it is reasonable to deduce that he will be guided to some extent by French experience of making both private and public industry accountable to a central planning organization. In particular, he said, during his concluding remarks, "French experience in bringing these plans [those of private industry] as well as those of the public sector together, and determining national policy on the basis of a four-year investment plan, throws up possibilities for this country." He added that such planning need not involve detailed interference with individual company decisions, since the Government already has extensive means, through its tax powers and through decisions about its own expenditure, of influencing the pattern of investment growth and the future course of the economy.

The influence that Sir Robert's ideas can have must depend upon the terms of reference of the National Council for Economic Development (in practice, these could turn out to be a near-emasculation of the Council) and, again, on the director-general's own terms of reference within the Council. One must hope, however, that the Chancellor of the Exchequer has appointed a director-general with whose views he is now broadly in agreement, and that Sir Robert Shone would not have accepted the appointment if he had not seen it as an important and real factor in national economic planning.

International Apprentice Competition, 1962

Plans are now being made for the selection of the British team to take part in the 1962 International Apprentice Competition. The date and place of the competition proper will be announced early in the New Year but, meanwhile, it has been decided that the British team will be picked after selection tests to be held between March and May.

The competition has extended its influence since it began in 1951 as a purely Iberian affair, with both Spain and Portugal submitting entries. Spain is still the home of the competition's governing body—the Organizing Committee of the International Apprentices Vocational Training Competition—but by last year there were eleven competing countries. British apprentices did well in 1961, the 31 entrants winning two gold medals, seven silver medals and three bronze medals, but it is hoped that they will fare better next time.

It is expected that the 1962 competition will include the following trades: fitting, turning, milling, oxy-acetylene welding, electric welding, cabinet making, joinery, carpentry, brickwork, plumbing, sheet metal work, wood patternmaking, wrought iron work, radio fitting, house painting, stone cutting, silversmithery, jewellery, machine design draughtsmanship, house wiring, foundry moulding, and forging. Each trade will be divided into age groups.

Entries for the selection tests have to be made by March, and further information is available in Britain from the Director (IAC), City and Guilds of London Institute, 76 Portland Place, London W1.

No Speaka Da Lingo No Hava Da Business

The Three Counties Industrial Education Association (formerly the Gloucestershire Association, but now taking in Herefordshire and Worcestershire as well) continues to find ways of bringing industry and education together to their common advantage. In last term's issue of the association's newsletter, *The Link*, a foreword from the president and chairman, Lt.-General Sir John Evetts, includes a reference to the linguistic limitations of many engineers and announces a competition through which the association is to help to break down some of these limitations.

"We hear a great deal," writes Sir John, "about the need for Great Britain to enter the European Common Market. But . . . what is being done to ensure that our engineers are fluent in the languages of the European members of that market?" What the TCIEA is now doing about it is to offer a prize to the schoolboy or schoolgirl making the best unassisted translation of an extract from the French publication, *Le Métier d'Ingénieur*—none of this old-fashioned and sterile business about *plumes de ma tante* for the TCIEA.

Competitions of this type can undoubtedly help in educating engineers of the future to the necessity for knowing the other man's language in export trade negotiations. Unfortunately, too many engineers of the present passed through the educational pipeline at a time when it was still blithely assumed that it was up to the other man to learn English. This is an attitude that is now seriously impeding our export trade.

The Link also gives some interesting conclusions from a series of conferences held during the year on Better Opportunities in Technical Education. One of these conclusions is that craft apprenticeships are too long in the context of modern industry and modern training methods. This is an opinion for which there is now a considerable body of support nationally, as was demonstrated at the recent weekend conference held by the British Association for Commercial and Industrial Education and the Industrial Welfare Society (ENGNG., 8 Dec., p. 736).

The TCIEA also concludes—and here it has the experience not only of the apprenticeship policies of its constituent firms, but also of its own group apprenticeship scheme—that "there should be some standard of inspection of all apprenticeship schemes." So far, this is only a very vaguely expressed idea, but it must surely be that any move to eliminate the wastefulness of poorly organized and conducted apprenticeship schemes will help to insure that our most valuable raw material—human skill—is fully utilized.

A National College of Agricultural Engineering

Next autumn, the first twenty students of the National College of Agricultural Engineering will begin the first three-year course leading to associateship of the College, an award which, it is intended, will be equivalent to a general degree. For their initial year, students will be housed at the Mechanized Farming Centre, near Chelmsford, which has been made available by the Ford Motor Company. By the following year, the major part of the College's own buildings will have been completed at Silsoe, in Bedfordshire, and there will be residential accommodation for 100 students, some of them from overseas.

The creation of the National College has been made necessary by the growth of the agricultural engineering industry (it has a £128 million a year export trade and is going to be increasingly important in the fight against world hunger) and by the lack of an undergraduate level course which tackles agricultural engineering as an academic discipline in itself. The three-year course for the associateship will be the college's basic course—its Principal, Dr. P. C. J. Payne, says that "it is the avowed intention to build this into the best undergraduate type training in professional agricultural engineering obtainable anywhere in the world"—but there will also be tailor-made one-year and two-year post-graduate courses.

There is strong support for the college in the farm machinery and the farming industries and several manufacturers have made generous loans of farm mechanization equipment (at this season of goodwill only a cynic would say that they would be fools if they didn't). There will also be invaluable help from the National Institute of Agricultural Engineering which will be the college's neighbour at Silsoe. The chairman of the college's governing body is Sir Gilbert Flemming, K.C.B., and the other governors have been nominated by the Ministry of Education, a number of professional and trade organizations, the TUC, the FBI, and various government departments.

Until the beginning of the 1962-3 academic year, the college's temporary address is Queen Anne's Chambers, 28 Broadway, London SW1.

Wrong End of the Industrial Relations Stick ?

This month the Minister of Labour, Mr. John Hare, has been meeting employer and union representatives from the motor and shipbuilding industries, two of the industries worst hit by strikes. In the case of the motor industry this was a follow-up of meetings held last April.

The most significant outcome of the meeting held with the two sides of the motor industry early in the month was that both the employers and the unions joined the Minister in a general condemnation of unofficial strikers. Indeed, from the official report on the meeting, it seems that most of its time was taken up in a round of self-congratulation on refusing to give in to the "unconstitutional action" of unofficial strikers (from the personalities involved, the Acton strike was very much in mind), instead of in considering the real reasons for strikes.

Perhaps it is symptomatic of the poor strike record in the motor industry that whenever an unofficial strike occurrs both management and unions regard it as an act of God—or, rather, of the devil—instead of as a manifestation of the failure of their own policies. Even the most bloody-minded agitators cannot agitate successfully unless there is something to agitate about, if only sheer remoteness. Any management or union which does not see this is, surely, indulging in the most arrogant and wasteful self-deception.

In short, the Minister is to be congratulated on the new found mateyness exhibited by the leaders of the employers and of the unions, but it will get the country nowhere if this, in some ways happy, state of affairs is attained by the simple expedient of pretending that anything that does go wrong is outside their control.

When the Minister met the shipbuilding employers and unions later in the month it was little more than a preliminary skirmish in which both sides were probably concerned chiefly with sizing up each other and the Minister. Nevertheless, the very fact that this first meeting has been arranged is an important first step in improving relations in the industry. Indeed, this first meeting might already have achieved something in agreeing to set up a working party—under the chairmanship of Mr. P. H. St. John Wilson, Deputy Secretary, Ministry of Labour—to consider practical measures for improving relations in the industry and its competitiveness, and to report back to a later meeting of the main conference.

Supercharged Anglia Anticipates Revival

Supercharging, popular before the war, has been out of favour in recent years. Now a revival is evident and a few stock models are listed again. The example described presents a lively alternative to conventional tuning.

DURING recent years a minor motoring revolution has taken place in the form of a growing trend towards improved performance for popular cars, particularly in the smaller capacity classes. Large numbers of cars in various stages of tune are appearing on the roads and some of them offer a very brisk performance.

This has taken place rather at the expense of the genuine sports car with its manifest disadvantages of high costs, rudimentary protection from the elements and limited accommodation for both luggage and passengers. The sports car industry still thrives but the greater part of its output is now mass-produced and some of the smaller manufacturers have been forced to double up with some more lucrative form of business.

One such concern is the Allard Motor Company, best known, perhaps, for the exciting V-8 engined creations of its founder Sydney Allard. But these cars are no longer made and the firm has reverted to the sale of Ford cars and the world distribution of Shorrock superchargers.

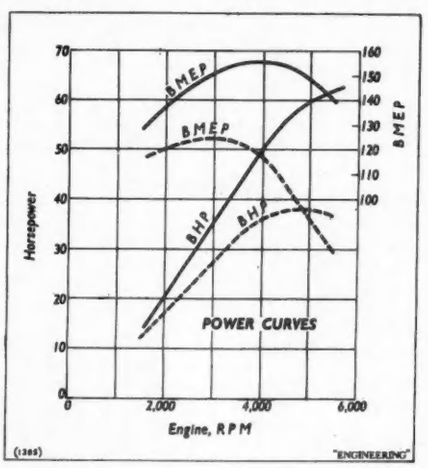
ENGINE OPTION

A marriage of these two—Ford cars and Shorrock superchargers—has resulted in the latest of the line to bear the company's name. In fact two cars are made, both based on the Ford Anglia. One is fitted with the 109E 1,340 cc engine in its standard form and the other with the supercharged version of the 997 cc 105E.

The supercharger employed is the C75B, a belt-driven vane type unit suitable for almost any engine up to 1100 cc. It is fed by a 1½ bore SU carburettor and the boost pressure is normally around 7 lb per sq. in although this is a function of the ratio of the driving pulleys. Automatic lubrication is tapped from the pressure side of the engine system via a built-in metering valve. As a form of tuning, supercharging increases the fluid pressure of the working stroke and thence gives the impression of larger capacity, rather than inducing more power by increased rpm. Hence the relative performance of the two cars is not dissimilar, but the supercharged version seems more lively and better suited to the Ford company's well-known publicity slogan.

Outwardly the Allardette is not easily distinguishable from the Anglia. Wheel trim treatment is different, the front number plate is mounted on the bonnet panel and a combined fog and spot light is placed below the front bumper. Close inspection underneath reveals disc brakes, an anti-roll bar at the front and an extra leaf in the rear springs. The interior is a little more pretentious, with a row of auxiliary instruments, a recalibrated 105 mph speedometer, revolution counter and a well finished wood-rimmed steering wheel.

There is a widespread prejudice against supercharging as a means of increasing engine performance. This is largely based on a misconception which associates it with large, noisy, unreliable pre-war racing cars which, though fast, consumed vast quantities of fuel and had very little practical value to the average motorist. A short run in the Allardette will dispel any fears of such an association. The supercharger is most unobtrusive and apart from a slight, but not unpleasant whine, (particularly noticeable on the car tested) it gives little or no indication of its presence at low engine revolutions.



Relative outputs of the Ford 105E engine in standard form (shown dotted) and supercharged (unbroken line).

Around 3,000 rpm however one becomes aware that this is no ordinary Ford Anglia and the car accelerates smoothly and rapidly up to its maximum of about 6,000 rpm. There is no appreciable increase in the revolutions available as there would be with a tuned atmospheric induction engine, since the function of the unit is to increase the bmep, resulting in power without revs and greatly improved tractability in top gear.

Allards also claim that there is little practical evidence to support the allegation of unreliability and premature wear. Valve burning and carbon build-up are minimized as the engine runs more efficiently and cylinder combustion is more uniform. Also, the oil-mist from the supercharger lubrication is said to reduce bore wear. Big-end loading is increased by the magnitude of the boost pressure but the detrimental effects are no greater than they would be with a slightly increased compression ratio.

With the solution of heat-flow problems, improved valve materials and the introduction of the steel-backed bearing, the production engine has become far more rugged than it used to be. There appears to be, therefore, a case for a wider application of supercharging as an alternative to the more established technique of modifying the engine to improve the gas flow and thereby obtain more power by higher rpm.

There is also an appreciable reduction in vibration as the rotating mass of the supercharger rotor, driven by a V-belt from the nose of the crankshaft, acts as damper giving the effect of a flywheel at both ends.

The power curves shown in the accompanying diagram indicate the extent of the improvement in performance which can be expected from a supercharged engine. Power is increased by about 56 per cent, but the peak is reached at only slightly above the standard engine's maximum output speed. The bmep is not only increased but a higher figure is maintained over a longer speed range.

On the road, the Allardette combines a useful performance with good manners. The improved torque enables greater use to be made of top gear and it is possible to come down almost to walking pace without snatch. Such flexibility is a boon in heavy traffic when the engine may have to be made to pick up from under 500 rpm.

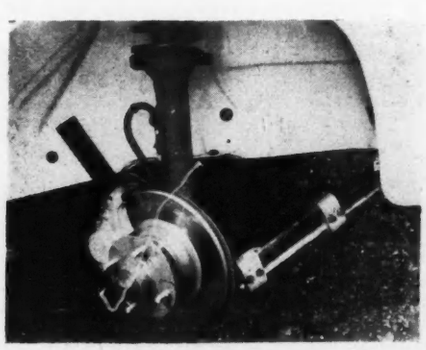
LIVELY PERFORMER

Acceleration through the gears and in top gear is much improved, the 30-50 mph figure coming down from 16·1 to 9·1 sec; 0-70 mph through the gears is almost halved at 22·25sec and the maximum speed goes up from just under 74 mph to over 90—which is ample for this design of car. All this improvement is not without a premium for the fuel consumption is increased by 30 per cent to around 28 mpg.

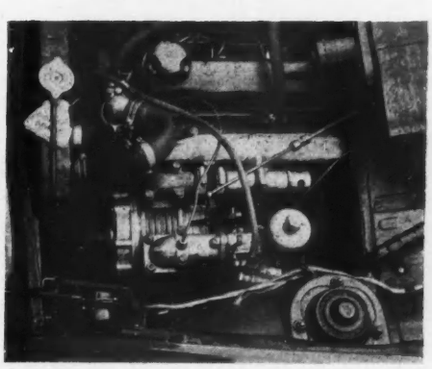
On the road, the disc brakes were found to be powerful and progressive, stopping the car repeatedly in a straight line without any trace of fade. Higher pedal pressure was required than on the standard car but this was not tiring and tended to obviate snatch and the possibility of skidding on a wet road. These brakes are of Allard design, and the hubs and discs are indigenously produced. The caliper mechanism is by Girling.

The suspension modifications had little adverse effect on riding comfort, but a reduction in roll and general improvement in handling was noticeable. Power to spare in the engine gave added confidence when cornering near the limit of adhesion.

The supercharged Allardette is offered as a stock model, a common enough practice before the war but now comparatively rare. However there is nothing to prevent all or parts of its specification being incorporated into any car either new or used. A supercharger has much to offer to the motorist who, for reasons of finance and space requirements, is limited to a small family car which lacks the sporting characteristics he desires. Fitting the supercharger provides an unobtrusive means of boosting performance without loss of practicability. In addition, no extensive modifications to the engine are required and the unit may be removed to return the car to standard specification if it is to be sold and replaced by a new model.

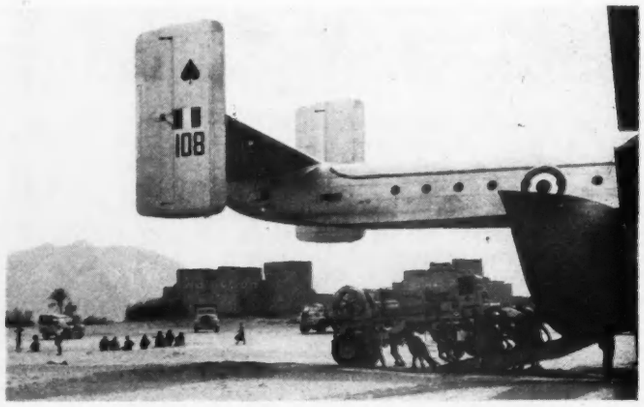


Roadholding of the Allardette has been improved by the fitting of an additional anti-roll bar. Braking is made commensurate with the improved performance by disc brakes designed by Allard.



Installation of the supercharger is a simple matter and requires no dismantling or structural alterations. In place, the unit fits neatly and in no way impairs accessibility.

Laying a hardstanding for RAF Comets and Britannias.



Unloading construction equipment from a Beverley freighter.

Construction Services within the RAF

Civil engineering needs of the RAF are partly met from its own Airfield Construction Branch which comprises a number of mobile and highly mechanized units.

THE AIRFIELD CONSTRUCTION BRANCH of the Royal Air Force was formed early in the Second World War to undertake the emergency repair of airfields in the United Kingdom which were damaged by air attack, but as the war progressed it was called upon to construct airfields and facilities in outlying areas at home and in overseas theatres. By the end of the Japanese conflict, the branch had grown to a strength of 30,000 officers and men, and squadrons were dispersed as far apart as Iceland, West Africa, the Azores and the Far East. In addition, it contributed some 3,000 engineers to the North West European campaign.

The numbers were rapidly reduced by demobilization in 1945 and 1946, but a nucleus has been retained ever since and the branch is now accepted as a permanent arm of the Royal Air Force. It is a highly mechanized unit that can be rapidly transported by air to any part of the world where urgent work is required.

In the intervening years this smaller force has figured in nearly every international crisis involving Royal Air Force operations, such as the Berlin Air Lift, when a programme of major works was carried out in Western Germany; the Enosis campaign in Cyprus and the Suez emergency, when it was necessary to maintain essential services and carry out urgent construction work in support of these operations after the withdrawal or defection of locally employed native labour and contractors.

REMOTE SITES

The branch exists, therefore, for the maintenance and construction of Royal Air Force installations in war or local emergency in any theatre of operations; and in peacetime the branch is often deployed to remote areas where for economical, political or topographical reasons it is impossible to employ contractors. It was for this reason, for example, that the branch was called upon during the summer months of 1957 and 1958 to construct a base installation on the storm blown island of St. Kilda in the Outer Hebrides and in Benbecula in South Uist. There, among other works, a steel and concrete jetty was constructed through which all stores for the NATO rocket range on the island, could pass. A little remote from airfield construction maybe, but an indication of the wide range of projects with which the branch is confronted.

In overseas theatres such as the Arabian Peninsula, construction is generally more rudimentary, often because of the difficulties of getting suitable plant, equipment and stores to some of the more inaccessible stations. Many of these remote stations are supplied entirely by air. Sometimes heavy plant is essential when more permanent runway pavements are required and use is made of the enormous Beverley freighters, as illustrated, to deliver equipment and stores.

All squadrons are provided with a wide variety of modern construction plant and equipment and can undertake most types of construction work within their manpower capability; frequently materials have to be won from mother earth, virgin quarries opened up and crushers installed to provide the various sizes of stone required for concrete or asphalt mixes.

It is in the United Kingdom that the greatest opportunity arises for producing the high quality concrete or asphalt pavements required by Air Ministry specifications. It was at Royal Air Force Lyneham, for instance, that a Construction Flight recently laid an 11 in concrete pavement to extend the existing hardstanding to permit the operation of the Comets and the Britannias now in service with the RAF's Transport Command. A central batching and mixing plant with modern concrete spreader and finisher were essential to produce the high quality concrete and the final surface with excellent riding qualities which are now required.

In asphalt work on aircraft movement areas the Air Ministry has adopted the Marshall Test Standards for asphalt, which call for the careful selection and grading of aggregates to obtain the desired mechanical stability. For this exacting work the branch uses, among others, a 50 ton mixing plant modified by its own development team to provide additional cold bins for the aggregates, while laying and rolling are undertaken with standard commercial equipment.

Just recently, the branch has taken possession of its first mobile laboratory, the interior of which is illustrated on the opposite page.

On some runways it has been found necessary to produce transverse grooves in the finished surface to break the water film and so prevent aircraft with high tyre pressures and high landing speeds aquaplaning when landing on a wet runway. As was described in the Press at the time of the Farnborough Air Show, grooving of runways has been accomplished so far by cutting the finished pavement surface. Recently the development team has produced effective surfaces by using a vibrating roller modified with suitable annular rings to produce the grooves, although the optimum conditions under which this should be carried out are still the subject of further investigation.

WORKSHOPS AND TRAINING

Whilst the emphasis has been placed so far on the civil engineering side of the branch's work, no less important are the electrical and mechanical engineering aspects. In local emergencies, the branch has quite frequently been called upon to instal and run electrical generating plant to keep functioning the essential services on a station, and in peace time it undertakes electrical installations in buildings and fitting of central heating plant and services.

At the Airfield Construction Depot in Warwickshire there exist well-equipped workshops where the repair and servicing are carried out of all types of airfield construction plant in use, by this branch and the Air Ministry Directorate-General of Works. A comprehensive range of workshop and general engineering facilities is provided, including machine tools for metal and woodworking, welding plant, electrical and hydraulic testing rigs.

It is at this depot that all tradesmen serving in the branch receive their training and young

The airfield construction branch of the RAF has its own workshops which are closely connected with one of the few construction plant schools in the UK. Training is given in plant operation and maintenance.

engineer officers, recently graduated, learn the application of their university training to airfield engineering before going out into the field to gain the practical experience necessary for membership of the major professional institutions. Here, too, is one of the few construction plant schools in the United Kingdom, where the recruit is given basic training in the operation, maintenance and repair of tractors, excavators, rollers, graders, compressors and all the other equipment required on site.

PADS FOR VTOL

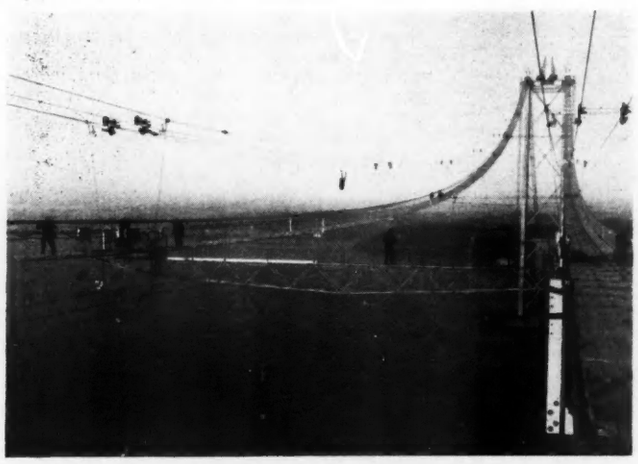
But what does the future hold for the military airfield engineer? The aircraft industry having for many years built larger and faster high-performance aircraft, requiring even longer and stronger runways, is today directing its development effort into the field of the vertical and short take-off and landing type of aircraft (VTOL and STOL). The military uses of the VTOL aircraft are obvious but must be related to the very high fuel consumption at take-off to gain the vertical lift, and STOL techniques will probably be used wherever sufficient space permits. What is apparent from this development is the likelihood that these aircraft will be able to operate from natural surfaces which have received a minimum of preparation, but this gives rise to the problem of surface erosion due to the downward thrusting jets, coupled with that of dust alleviation.

And so from the realms of crater filling and the construction of temporary grass runways, sometimes overlaid with a prefabricated material, through the requirements of recent years for high quality pavements, the branch finds itself once more concerned with rapidly constructed airstrips, making the maximum use of the natural surface and local resources; highly mobile construction plant, transportable by air, is an essential backing for any force which has to cope with such tasks.

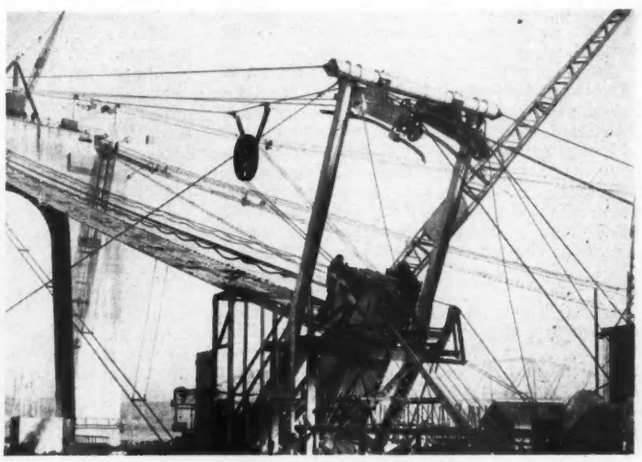
The officers and men who make up the force need to be imbued with a spirit of adventure and capable of exercising their engineering and trade skills in unusual situations, frequently where improvization may be important. In particular, the officers gain valuable engineering experience and, when coupled with the camaraderie of life in the Royal Air Force, the amenities both sporting and social on stations at home and overseas, the attraction of such a career cannot be denied.

Some aspects of the branch's work in various countries, together with some of its equipment and the part it plays within the Directorate-General of Works, will be demonstrated in an exhibition which the Air Ministry is staging in Whitehall. The exhibition, which will cover all aspects of the Directorate's work, will be open to the public from 9 to 13 January 1962.

Inside the ACB's new mobile laboratory.



The catwalks and tramways across the main span.



The spinning wheel departing with four bights of wire.

Cable Spinning Started on the Forth Road Bridge

For the first time outside North America, cables for a major suspension bridge are being spun into position. On the new road bridge across the Firth of Forth, each main cable will consist of more than 11,500 parallel wires (of 0·19 in diameter) of galvanized high tensile steel; when complete a cable will be 22½ in in diameter.

The wire was made by Dorman Long (Steel) Limited at Middlesbrough and delivered to the site in 10 cwt coils. Prior to spinning, the wires were wound on to drums made to carry 7 tons of wire, the coils being spliced together by cylindrical nipples squeezed in a 200 ton press. To start spinning, the loaded drums, in batches of eight, are mounted on unreeling machines set up behind the south anchorage. Four wires are then drawn off the drums, taken through the tensioning towers and tied back to a strand shoe in the anchorage; the loops of the wire are passed round the spinning wheel—clearly shown in the illustration—and arrangements are then ready to take the wires across the river.

The spinning wheel is carried on an endless cable that runs from the south anchorage over the south side tower, over the main towers and down to the north side tower and north anchorage, and then back to the south anchorage. Synchronized drives—used for the first time on the Forth Bridge—unwind the drums and take the spinning wheel across the river, carrying four bights of wire with it; simultaneously a second empty wheel returns from the north to the south.

When the four bights reach the north side, they are taken off the wheel by hand and looped on to the strand shoes at that end. During the spinning operation, men are stationed at 400 ft intervals along the catwalks and it is their duty to adjust the wires and lay them against a fixed guide wire, so ensuring that all the wires are placed with a constant sag in the main and side spans. The spinning wheels travel at the high speed of 700 ft per min (8 mph) which enables four bights (eight wires) to be erected every 18 minutes.

After all the wires—on average, 314—for a strand have been put into position, they are combed into alignment and banded together, the final adjustment being done at night when the temperature will be sensibly constant along the full length of the bridge. The process is then repeated until the 37 strands in each cable are finished. With all the strands in place, the cables will be compacted by four hydraulic rings that will move along the cables, squeezing the wires hard together at intervals of 3 ft. Finally the cables will be clamped in the machined cast-steel saddles on each main tower. With that work complete, cable bands will be put into position at each panel point ready to receive the long suspenders which will carry the deck structure. (For the Forth Bridge, the suspenders are being made true to length and no form of adjustment is being installed.) The last operation on the cables, after most of the deck is erected, will be to paint and wrap each cable with protective tapes and binding wire; this will be done by fast moving wrapping machines.

A general, though detailed, description of the superstructure of the bridge was given in ENGINEERING for 31 March '61, pp 448 to 454. The bridge is being built for the Forth Road Bridge Joint Board by the ACD Bridge Company, a consortium formed by Sir William Arrol and Company Limited, the Cleveland Bridge and Engineering Company Limited, and Dorman Long (Bridge and Engineering) Limited. The consulting engineers are Mott, Hay and Anderson, and Freeman, Fox and Partners, both of London. Advice on the spinning technique has been obtained from Roebling of Tranton, USA, the company founded by John A. Roebling who originated the cable spinning system when he built the Brooklyn Bridge in New York in 1883.

Promise in the Cold Light of Cryogenics

The science of cold production now unfolds in a complex industry to meet demands for atmospheric gases on a large scale and for the application of low temperature itself.

CRYOGENICS became one of the glamour industries of the late fifties through the dialectic of oxygen supply and demand. It was the famous explosion in the use of oxygen for steelmaking and rocket propulsion that made it possible to develop cheap bulk-production and distribution techniques for cryogenic liquids and pure gases. The reduced cost in turn energized entirely new fields of demand as far away as food processing or the manufacture of fertilizers.

It is now clear that the boom in cryogenics rests on firm foundations, much firmer than would be provided only by the demand for rocket propulsion, and hence the cryogenic industry can be expected to continue to grow faster than the average growth of national product.

Any fast growing industry provides good opportunities for doing business, but what makes cryogenics particularly interesting is the fact that it affects almost all manufacturing industries through the compound levers of supply and demand.

Many industries benefit by the utilization or adaptation of cryogenic techniques, but the same industries can generally put to good use their traditional skills in filling the specialized needs of low temperature work. This is in interesting contrast to many other fields of engineering, for example transportation, where new developments affect almost exclusively the demand side of a firm's business while leaving the supply aspect for all practical purposes unaffected.

METALS LIFTED BY BOOTSTRAPS

Linz-Donawitz, Kaldo, and Rotor, the recently developed oxygen-processes for steelmaking, were the prime movers of the cryogenic revolution. Since then, the use of oxygen has been extended to a few other important metallurgical applications, notably in blast furnaces and copper refining.

The use of oxygen increases the productivity of steel plants enormously and will eventually lead to reduced steel prices while ensuring a large and steady demand for oxygen. But the supply aspect of oxygen in metallurgy is well documented elsewhere; here only the demand aspects will be considered, in particular the effect of cryogenics on the demand for metals.

Embrittlement of carbon steel at low temperature makes it unsuitable for cryogenic applications: the traditional material of the early users of very low temperatures was therefore copper, which is still used extensively in laboratory work or pilot-scale plants. But with the increasing size and severity of services for cryogenic apparatus the high cost and relatively low strength of copper made it less and less attractive. Today copper is used in appreciable quantities only in tube or sheet form for the numerous heat exchangers and distillation trays needed in low temperature gas separation plants, and even there copper's position is insecure.

The first successful competitor of copper was stainless steel, in spite of its high cost arising from a superfluous corrosion resistance. With stainless steel, vessels of large size could be designed and fabricated with relative ease. Stainless steel and copper have almost the same low temperature coefficient of thermal expansion, so that the two materials could be readily combined into efficient heat exchangers: stainless steel made a strong and light low-conductivity pressure shell, while copper served as an easily workable heat transfer surface of very high thermal conductivity.

What seemed for a while like a captive market for stainless steel was soon invaded by two new materials: aluminium and 9 per cent nickel steel. Aluminium is perhaps the ideal material for low temperatures: like most metals, aluminium's strength and yield point increase with falling temperature, but unlike other metals, some aluminium alloys show no sign of reduced notch-strength.

WHAT KIND OF FABRICATOR?

It has been suggested that the volume of business transacted by the low temperature specialists will rise from £180 million in 1960 to some £350 million by 1965. The increase is bound to provide many new opportunities to fabricators in the supply of low temperature equipment necessary for the transaction of this business. There are two ways in which a novice can enter the field: he can do it under contract or licence, supplying low temperature plant components or transport and handling equipment to the designs of a specialist; or by producing an independent line of competitive commercial products.

The fabricating shops that have the best chance of success in cryogenics are those that already have accumulated experience in working with stainless steel and aluminium, and have some background in gas and vacuum-tight fabrication. No heavy shop equipment is needed as plate thicknesses rarely exceed $\frac{1}{2}$ in steel or its aluminium equivalent, with the majority of the work being in the $\frac{3}{16}$ to $\frac{3}{8}$ in steel range or its aluminium equivalent.

The metal fabricating business can be conveniently divided into the production of low temperature gas separation plant components on the one hand and cryogenic liquid storage and distribution equipment on the other.

In essence a gas separation plant consists of a few relatively simple distillation columns, a large number of heat exchangers, and the interconnecting piping. The heat exchangers are somewhat out of the ordinary because pressure drop, heat leakage, and the irreversibility of finite temperature difference are all very expensive in low temperature work. On the other hand the fluids handled are of a very high purity with practically no entrained solid particles, so that passage dimensions or tube internal diameters of $\frac{1}{4}$ in are commonly employed.

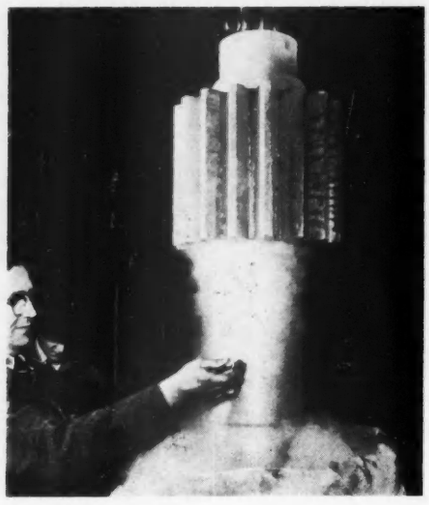
The heat exchangers are extremely compact. Sandwich cores obtained by brazing corrugated stainless steel or aluminium sheets to flat sheets are used extensively for pressures up to 100 lb per sq. in, and more rarely up to 500 to 600 lb per sq. in. Tubular heat exchangers of a special design compacted by twisting the tubes into many layers of helical windings are used up to 5,000 lb per sq. in; and some companies use very large straight-tube condensers at pressures up to 100 lb per sq. in.

LIQUEFIED GASES

Cryogenic liquid storage and distribution vessels are a slightly different kettle of fish. These liquids are stored or transported over long distances at temperatures perhaps 400°F below ambient and hence require very good insulation, usually in the form of a high-vacuum jacket filled with a fine powder or layers of metal foil with interleaved separators as radiation barriers.

Some of the cryogenic liquids find end-use in liquid form, usually for the provision of very low temperatures. But the market for cryogenic liquids with end-use in gaseous form is far greater.

Quite well established is the sale of oxygen in liquid form to hospitals and engineering shops. In such cases, in addition to a liquid storage tank, the installation is equipped with pipe-coils and regulators in which the oxygen is evaporated and warmed by absorbing heat from the atmosphere. A smaller pressure-controlled heat transfer coil is also mounted on the tank, which serves to raise the pressure of the tank to the required distribution pressure in the fashion of a steam generator. The installation is completed by a distribution network of pipes.



Liquid nitrogen shrinks a gear wheel spigot at Bayliss, Jones and Bayliss Limited, Wolverhampton.

Airborne installations of a similar kind are becoming increasingly widespread, and the Vickers VC 10 will be the first commercial aircraft equipped with an emergency supply of liquid oxygen and atmospheric converter. The suppliers of the equipment are Normalair Limited of Yeovil, Somerset.

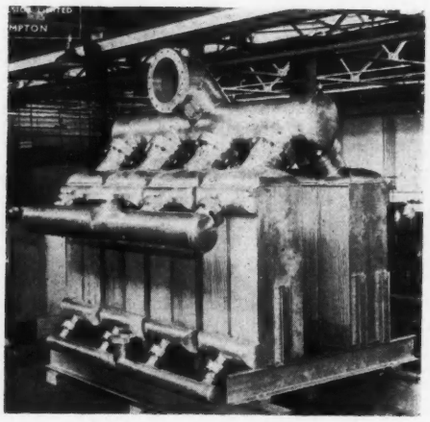
An application of very great potential for liquid nitrogen is in the transportation of frozen food-stuffs over long distances. At present cargo-trucks or railway wagons equipped with mechanical refrigeration plants carry these goods. But in the United States the Howell Trucking Company operate one quarter of a fleet of 65 refrigerated trucks with cold supplied from a liquid nitrogen storage tank instead of mechanical equipment.

The installation is very simple, consisting of the storage tank, a thermostatically controlled valve on a pressure raising coil, and a system of spray nozzles that cool the cargo by spraying it with liquid nitrogen. The direct operating costs are only slightly higher than with mechanical refrigeration in spite of the monumental thermodynamic inefficiency of cooling foodstuffs at 0°F with a liquid at −320°F. But maintenance is practically nil, there is considerable saving on installed capital cost, and owing to the much lower temperature to which the cargo can be refrigerated spoilage is greatly reduced.

An independent fabricator wishing to market cryogenic equipment on his own has the best chance of success in making low temperature storage vessels or "converters". In the United States, where defence spending on cryogenics is high, there are a number of shops specializing in this type of work.

The only additional piece of shop equipment needed to enter the market is a good leak detector: either a halogen detector or a mass spectrometer. The former is relatively cheap at around £178, but must be used with a certain amount of caution as it frequently reacts to atmospheric fumes. The mass spectrometer is much more sensitive and can be used in a fume-filled shop, but costs around £1,000 and uses expensive helium to detect the leaks.

On the demand side of the account the fabricators are affected by the cryogenic boom chiefly through the reduced price of industrial gases



A Marston Excelsior oxygen plant heat exchanger.

achieved through the economies of large scale production and bulk distribution in liquid form. Oxygen, nitrogen and argon are now being distributed commercially in liquid form, and at least one shipment of liquid neon has been made to a customer. Argon-shielded arc-welding and fabrication of exotic metals under an argon atmosphere will make advances under the influence of lowered prices.

Liquid nitrogen is also playing an increasingly important part in the metal fabricating shop. Shafts can be shrink-fitted into complex castings, which would distort if heated, by immersing the shaft in liquid nitrogen. Glued aluminium or stainless steel honeycomb structures, used extensively in high-speed aircraft as lightweight structural members, can be reclaimed from the scrap-heap through immersion in liquid nitrogen. At very low temperatures the bonding glue embrittles and the rejected structure can be " dismantled " by giving the chilled component a few jarring blows.

The use of liquid nitrogen for high-pressure gas testing of intricate pressure vessels—where internal leaks would be hard to detect with a hydrostatic test—is becoming increasingly widespread. The liquid can be compressed relatively cheaply to any desired pressure and then evaporated and raised to the testing temperature before passing into the test-vessel.

Recently discovered metallurgical changes that occur when a metal is stretched at low temperatures will also stimulate the consumption of liquid nitrogen in metal shops. A relatively new application, low temperature stretching results in very favourable properties for certain steels.

EQUIPMENT MANUFACTURERS

Equipment manufacturers also benefit from the cryogenic boom, both as users and as suppliers. The development of low-noise electronic circuits, microwave ultrasonics, low-loss magnetic coils, bearingless gyrocompasses using magnetic levitation, frictionless bearings using the property of superfluidity of liquid helium-4, or the development of commercial mobile fuel-cell installations using liquid hydrogen fuel would not be possible without cryogenics.

Manufacturers of conventional equipment are also directly involved in the expansion of the cryogenic industry. The starting point of any low-temperature gas-separation or liquefaction process is a compressor installation in which one or several of the gases are compressed to initiate a refrigeration cycle. As the presence of oil is always a hazard in equipment processing oxygen-rich mixtures, the development of oil-free compressors and boosters would greatly improve the competitive position of a manufacturer.

Although there are several unlubricated reciprocating compressors in operation there is plenty of scope to reduce cost and improve reliability. The alternative approach—marginal lubrication, or the gradual reduction of lubricant until starvation is reached—is also not entirely satisfactory and may lead to dangerous peaks in hydrocarbon carryover, a condition more hazardous than the one being eliminated.

For similar reasons of safety from hydrocarbon carryover there is a lively interest in oil eliminators that would continuously remove all sizes of hydrocarbon droplets. Recent introduction of the Brink Mist Eliminator, developed at Monsanto Chemicals Limited, offers one solution to the problem. The radial inflow cylindrical cartridge of the Brink-element traps the oil droplets by Brownian diffusion and impaction, and accretes the droplets until discous flow can occur. The oil can thus be drained continuously from the cartridge and theoretically the element need never be replaced.

Another method of avoiding oil contamination is to use centrifugal compressors. With the present state of the art such machines are available only for a minimum flow of about 400 actual cu. ft per minute ; below that, speed and leakage become unmanageable. There is a direct relationship between final compression pressure and minimum process flow, so that only very large plants can use centrifugal compressors for pressures above 40 atmospheres.

SPECIAL UNITS AND USES

There exists a market also for more specialized equipment with a definite cryogenic orientation. An ever present component of low temperature plants is the expansion engine or turbine, where the compressed process fluids are expanded at low temperature to provide refrigeration. The expansion engines are usually low-speed double-acting single-cylinder machines operating unlubricated at temperatures of around −190° F. The turbines are small high speed wheels, of either radial inflow, or more rarely, axial, operating at speeds as high as 60,000 rpm and with gas-bearings or warm oil-lubricated bearings mounted outside the insulation.

Low temperature transfer pumps are used in large numbers both in gas separation plants and in the transportation of cryogenic liquids. The requirements imposed on these pumps are ability to operate on saturated or boiling liquids with no cavitation, short cool-down times, and leak-tight shaft seals. As in the case of expansion turbines, no external lubricant can be used and the pumps should preferably operate interchangeably on liquid oxygen or liquid nitrogen, the latter having very poor lubricating properties.

Higher pressure cryogenic liquid pumps are frequently used where the end product is required in gaseous form but in the range of pressures up to 500 lb per sq. in. These are usually vertical shaft multi-stage centrifugal pumps developed from the deep-well turbine pump design.

The increasing use of liquid nitrogen for pressure testing creates a demand for small single-cylinder reciprocating pumps for pressures up to 10,000 lb per sq. in. Owing to the intermittent nature of the operation low thermal inertia—and hence short cool-down time and low loss—are desirable features of these pumps.

There are several manufacturers in the United States offering small nitrogen generators for industrial or scientific use. These are package units comprising a refrigeration plant and a single low temperature distillation column that will produce from 5 to 100 litres per hour of pure liquid nitrogen. Such generators are used to provide low temperature environments for laboratory use, for the cooling of certain electronic circuits, freeze-drying of food, preservation of blood or possibly human limbs.

As a further development refrigeration units for liquid helium temperatures can be offered for use with liquid hydrogen or helium bubble chambers, superconductivity experiments, or the refrigeration of large capacity magnetic coils.

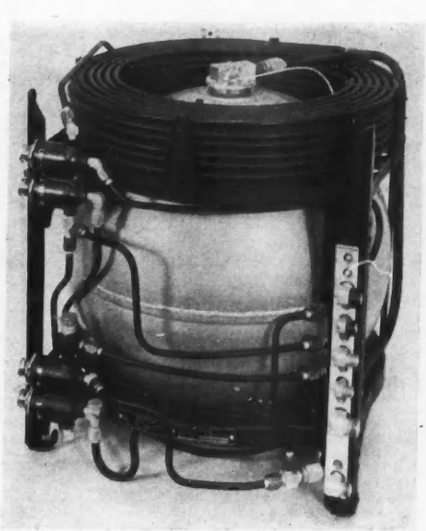
Control valves, safety valves, shut off valves and check-valves are needed in relatively large numbers in stainless steel or aluminium, with seals that will operate satisfactorily from 200°F to —320°F. Manually operated valves must be equipped with extended bonnets to project through the thick thermal insulation, and should incorporate some form of heat barrier.

Urgently needed for the safe operation of low temperature air separation plants is a simple instrument for the continuous measuring and recording of the quantity of each contaminant passing various points of the plant. All air separation plants draw varying quantities of hydrocarbon and other contaminants with the intake air. Those contaminants which have a low vapour pressure at liquid oxygen temperature, or those which have high solubility in liquid oxygen, will tend to accumulate in the reboiler section of the low temperature distillation column. After a period of operation the contaminant concentration will reach a point where the mixture in liquid oxygen becomes a dangerous explosive for which even trace quantities of acetylene can act as an efficient detonator. In spite of precautions guarding against the entry and accumulation of contaminants in an air separation plant, it is necessary to shut down the plant periodically for the removal of the dangerous materials.

Unfortunately, with present day methods the operators have only a vague idea of what the instantaneous contaminant levels are in the plant, while the detailed chemical analysis would be both slow and costly. It would be important to be able to monitor continuously the quantity of each contaminant passing various points of the plant, as tolerance levels differ widely for the various contaminants and sections of the plant.

In the United States a continuous hydrocarbon analyser using gas chromatography and a flame ionization gauge has been in operation for over a year at the air separation plant of the Rohm & Haas Company, and has given excellent service. There are over twenty different makes of gas chromatograph on the market, but there is no commercial adaptation available for the continuous and automatic monitoring of impurities in an air separation plant. The marriage of a gas chromatograph and a sampling device similar to that found in the faulty fuel element detection gear of gas-cooled nuclear reactors could yield a highly successful product.

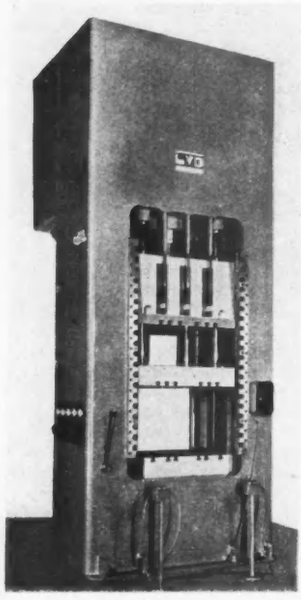
The cryogenic industry is in a state of flux comparable to electronics ten years ago. With the rapid expansion of business many new firms will spring up and get a foothold in the market, and those which start early enough will have a fair chance of survival when the great consolidation comes that is so typical of the growth industries, such as occurred in the electronics industry. But before supply catches up with demand, and before all technical alternatives for reaching an end have been explored and reduced to the optimum, there are tasks to be solved and there is business to be done in cryogenics.



Normalair 35 litre liquid oxygen converter for the Vickers VC10 aircraft.

DEEPDRAWING PRESS

Variable Operation



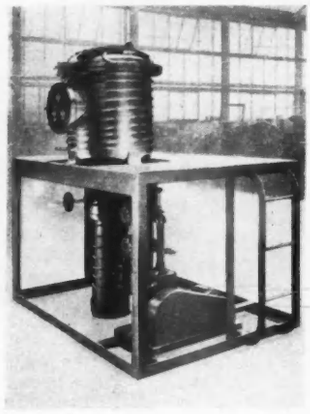
BELGIAN manufactured, LVD deep-drawing presses are now available in Britain. The model selected for illustration and description is the EMD150, which is a double action, double sided press. The maximum pressure of the punch ram is 150 tons.

Bed, crown, and the two side frames are of all-welded steel construction. The frame is normalized after welding but before machining. Slide faces of the guideways are lined with phosphor bronze. The drive is electro-hydraulic and allows for semi- or fully-automatic working. Pushbutton control stops the ram in any desired position.

A multiple-piston axial pump is mounted in the oil tank. Maximum stroke of the punch ram is 23½ in and of the blankholder 11½ in. The maximum pressure of the latter is 75 tons. Maximum distance from table to ram is 49 in. Measurements of the table are 39 in by 39 in, while the ram is 49 in by 39 in. *F. J. Edwards Limited, 359 Euston Road, London NW1.*

VACUUM BRAZING FURNACE

Packaged Unit



SUPPLIED as a packaged unit complete with control gear, an electrically heated cold retort furnace for brazing components in vacuum is now available from Royce Electric Furnaces.

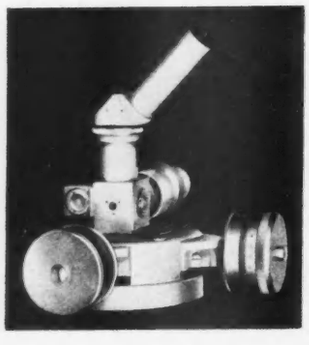
The furnace is fitted with a molybdenum wire element, which is reported to provide temperatures up to 1,200° C. The Edwards Speedivac pumping equipment, mounted beneath the operator's platform, is said to produce operating vacua down to 10^{-5} mm Hg. Work space in the furnace admits work up to 8 in in diameter and 8 in high, the charge being placed within the cylindrical element on a support made up from molybdenum rods with alumina top covers. The element operates at low voltage, derived from an infinitely variable voltage regulator transformer.

Water cooled, the furnace chamber is mounted on a floor-standing framework as seen in the illustration. The top plate of the platform has a height from the ground of 3 ft 7½ in. Access to the furnace chamber, which is a heavy-gauge steel cylinder, is obtained by removal of the domed cover.

Temperatures are controlled automatically; a recorder is housed in a wall mounting panel. Power requirements are 20 kW. Complete the unit weighs 35 cwt. *Royce Electric Furnaces Limited, Albert Drive, Sheerwater, Woking, Surrey.*

ALIGNING INSTRUMENT

Micrometer Sensing



THE Rodolite optical measuring device is claimed to enable accurate tests of alignment to be rapidly made, and all parallax errors to be eliminated.

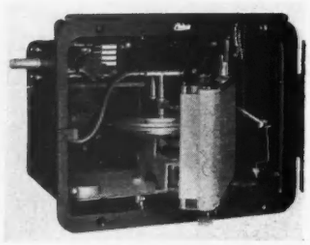
The instrument is available with a reflection grating or with a mercury pool. In the first case the grating is formed on the surface of a glass optical flat. In the second, a transmission grating is fixed close to the surface of a mercury pool; this behaves as a reflection grating which is always horizontal. Both types are said to define a straight line to within 0·0001 in over 20 ft.

The target remains in focus without instrumental adjustment at any separation from 6 in to 20 ft; x and y displacements from the line can be read directly from 0·0001 in micrometer drums. In the case of the mercury pool instrument, the setting accuracy is $\pm$ 0·00005 in. Changes in level of $\pm$0·05 seconds of arc can be measured when the sighting head is 15 ft from the pool.

Suggested uses with the reflection grating are: measurements on machine tools, checking straightness of machine guideways and parallelism in relation to an axis of rotation, and checking purity of spindle or table rotation. The mercury pool unit, when used as a vertical reference line, may be used to check cross-wind in vertical guideways. Employed as a plumbline, it can check yaw and pitching in carriages moving on vertical guideways, and cross-wind and pitching in carriages on horizontal guideways. *Cooke, Troughton and Simms Limited, Haxby Road, York.*

PRESSURE RECORDER

For Differentials



WALKER CROSWELLER have introduced a new type of Arkon differential pressure recorder, or indicator, to measure gas or air differential pressures up to 50 lb per sq. in and to withstand static pressures up to 125 lb per sq. in.

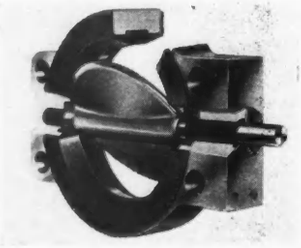
While the new instrument, illustrated, extends the makers' range of such recorders, this unit has a movement developed for the higher pressure range. To cope with these pressures a two-way slack diaphragm is included; a similar movement is already in use in the range but in the new unit it has been developed further to allow pressure differences to be measured. A thin brass diaphragm floats in a plastic sandwich. Two pressures are fed separately to the opposite sides and the net diaphragm movement is proportionate to the pressure difference.

A feature is the inlet valve which is operated by a single knob. This is reported to enable the instrument to be brought rapidly into operation in one movement without the possibility of incorrect sequencing. Recorded sections of the chart may be cut off as required, the free end feeding itself across the chart plate and automatically picking up on the collecting spool. Effective height of the roll strip chart is 6 in and length suffices for six weeks. Removal of the complete chart is said to occupy but a few seconds, should this be necessary to obtain access to the recorder mechanism. Indicating versions of the instrument are provided with a dial of 8 in diameter.

Chart drive can be by ac mains, or clockwork motor and flameproof electric drive (Buxton groups I, II, and III). If required, chart illumination and alarm contacts can be fitted. *Walker Crosweller and Company Limited, Cheltenham.*

BUTTERFLY VALVE

Rubber Lining Can be Replaced



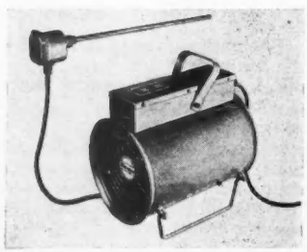
THE butterfly valve illustrated, which is known as the Continental Double R/L, has been introduced by the Fisher Governor Company; it is available in sizes ranging from 2 to 12 in.

Claimed to be an entirely new conception, the valve has a cast iron body and a rubber lining which is said to be easily replaced. The unit is stated to combine the simplicity and low cost of a butterfly valve with the tight-closing characteristics and reliability associated with stop valves. Bubble-tight shut off is guaranteed for pressures between 1·5 microns and 150 lb per sq. in. To suit differing conditions, a variety of rubber lining materials are available; these are offered for temperatures between −60° F and +400° F. It is said that average life expectancy with wet non-corrosive fluids is about 30,000 cycles.

The valve has a solid annular body into which the rubber liner is fitted. The liner is positively locked into the body, which it is reported precludes the possibility of the lining moving as the valve closes. As the lining covers both the bore and the face of the body the need for flange gaskets is eliminated. Sealing between the liner, valve body, and swing-through disc and shaft is effected by moulded liner-hubs, into which stainless steel retainers and O-ring seals are fitted. The shaft, which is continuous, is carried at each end on glass-filled Teflon bearing bushes. These are self-lubricating. Valve discs are normally supplied in aluminium bronze but are also available in stainless steel. Valve actuation may be manual, or power. *Elliott-Automation Limited, 34 Portland Place, London W1.*

TURBO HEATER

For Horticultural or Industrial Use



THE Humex turbo heater is intended for continuous operation in humid conditions associated with horticultural and some industrial situations.

Model HT/1 has a heating load of 1·5 kW, that of model HT/3 is 3 kW. It is understood that a 4·5 kW model will be available shortly. The heating element is of nickel-chrome, mineral embedded and totally enclosed in aluminium-bronze tubing. The fan is four bladed and 8 in in diameter. The unit is powered by a 200-250 V ac enclosed sprayproof BTH motor and is reported to be able to move 250 cu. ft of air per minute. Power consumption is 35 W.

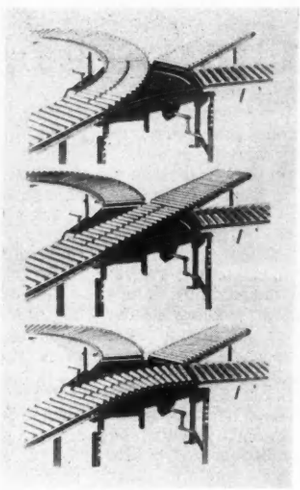
Thermostatic control is by a separate rod-type thermostat 24 in in length. The thermostat has a range of 0 to 90°F and is reported to have a differential of $\pm$1°F. It is connected to the heater by 9 ft of rubber-covered flex. In addition to the thermostat a bi-metal cut out, housed in a sprayproof terminal box fitted to the top of the heater, is provided. The thermostat cuts out both the heating element and the fan. At seasons when unheated air circulation is required, this can be obtained by manual operation of the air/heat switch.

Overall dimensions of the unit are: length 14½ in, height mounted on the legs shown in the illustration 15 in, width 10¼ in. The weight of the model HT/1 is 23 lb and that of model HT/2 22 lb rendering them easily portable.

The heaters are made from rustproofed sheet steel and have an interior heat-resisting finish of aluminium. Externally, a silver-grey hammer finish is used. *Roberts Electrical Company Limited, 11 High Road, Byfleet, Surrey.*

CONVEYOR SWITCH UNITS

Alternative Control



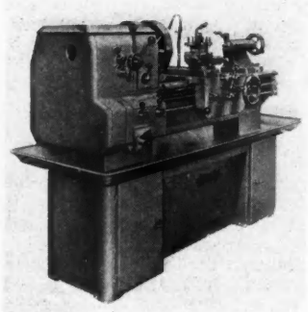
RAPISTAN flexible roller curve units, for three-way, Y, or spur conveyor line switching are now in production.

These units, which connect to gravity or power conveyors, may be hand operated or controlled remotely by electric motor. The three-way unit will divert 45° on each side; in addition to providing a straight flow; conversely it will allow materials from the three lines to be channelled to a common line. All three units are available for conveyors with widths of 12, 18, or 24 in.

Rollers are of 2 in diameter, 13 swg galvanized steel with plated unsealed bearings. They are pitched at 3 in centres when in the straight through setting and are reported to fan to true radial lines at any curve positioning. Rollers are arranged in two lanes to assure material alignment when passing round the curve. Should circumstances necessitate, rollers may also be pitched to aid the gravity flow of materials and guard rails can be supplied for the majority of requirements. When push-button control is employed limit switches disconnect the motor automatically. *Manufacturers Equipment Company Limited, Sutton Road, Hull, Yorkshire.*

CENTRE LATHE

Constructed to Schlesinger Limits



MADE in Sweden to Schlesinger limits, Startrite-Orn straight and gap bed centre lathes are now available in Britain.

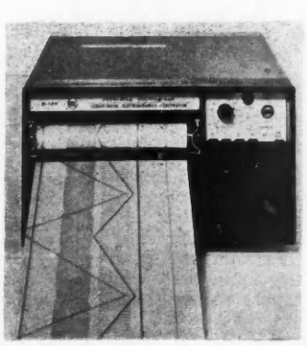
The Model 185GK illustrated, has a centre height of 7¼ in and is available with different bed lengths giving 30, 40, or 60 in between centres. The bed, which has scraped flat and inverted V slides, is hardened to 220/235 Brinell. A two-speed motor drives the headstock gearbox, which offers a range of 8 speeds, from 35 to 1,055 rpm, selected by lever. The spindle runs in double row roller bearings and thrust bearing. The spindle nose is American long taper key drive LOO for direct chuck mounting.

Carriage feed dials are graduated in 0·001 in. There are 36 longitudinal feeds and 36 cross feeds. Threads cut are 36 Whitworth 4 to 60 tpi and 16 metric 0·5 to 7·5. The Norton gearbox enables 11 of the metric threads to be cut without the use of change wheels, the remaining 5 are available with one change.

Faceplate diameter is 11½ in. Width of bed 10⅞ in. Swing in gap is 19¾ in and width of gap from faceplate 8 $\frac{1}{16}$ in. The bore of the spindle is 1 $\frac{3}{16}$ in and the diameter of the spindle at the front bearing 2⅜ in. The tailstock spindle has a No. 3 Morse taper. Tailstock travel is 5⅞ in. The leadscrew is 1⅛ in in diameter and has 4 tpi. Gears are high tensile, hardened and ground. Power transmission is by 4 V-belts. *Startrite Machine Tool Company Limited, Darland Hall, Star Mill Lane, Chatham, Kent.*

RECORDING OSCILLOGRAPH

Dark Room Eliminated



MADE in America by Consolidated Electrodynamics Corporation, the Type 5-124 recording oscillograph illustrated is now marketed in Britain.

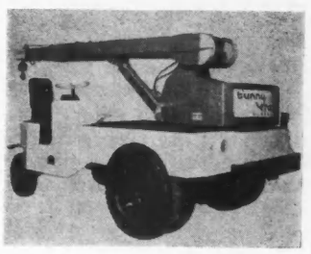
It is claimed that a feature of this machine is the simplicity of the recording section. The roll of self-developing photographic recording paper is inserted at the front of the unit. The need for a dark room is eliminated and there is no record magazine or paper threading. It is further claimed that the oscillograph is the most accurate so far produced and one capable of working to a very high precision.

There are 18 active data channels; 6 or 12 trace models are also available. Pushbutton controlled transmission provides record speeds of 0·25, 1, 4, 16 and 64 in per sec. The recording media is 7 in wide print-out paper; the maximum length available is 200 ft. Trace width is less than 0·01 in. Writing speed is claimed to be 50,000 in per sec. The optical arm is 11·5 in at zero deflection. The galvanometers, said to be readily adjustable, are CEC Type 7-300.

Dimensions are 7⅞ in high, 13 in wide, and 15½ in long, including controls and mounting feet. Weight is approximately 40 lb. Operating voltage is from 105 to 125 V, 50/60 c/s. When working on a 50 c/s power source recording speeds are $\frac{5}{6}$th of those mentioned. A large number of accessories is available. *Consolidated Electrodynamics Corporation (U.K.) Limited, 14 Commercial Road, Woking, Surrey.*

MOBILE CRANE

Hydraulically Operated



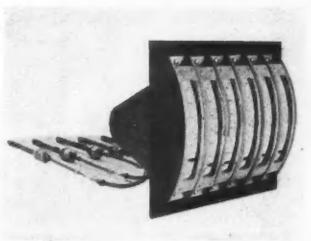
BASED on a Fordson Super Major tractor unit, a new 3 ton hydraulically operated mobile crane is announced by Tunny Cranes.

A feature of the design is the small amount of servicing required. There are only eight grease nipples and the rope pulleys have self-lubricating bearings. The hydraulic system is said to be arranged to eliminate any possibility of inching when the controls are at neutral and it is claimed that no damage can result to components from over or under hoisting, derricking, or slewing. Power is provided by a diesel engine developing 51·8 bhp at 1,800 rpm. Hydraulic power is supplied by a Vickers vane pump which maintains a system pressure of 1,550 to 1,650 lb per sq. in; the rated capacity is 8 gpm at 1,500 rpm.

Fluid is carried to the cylinders, which are double acting and have chromium plated rods, by Aeroquip hose. Hydraulic locks maintain pressure in the hoist and derricking cylinders should power fail. Lowering is power controlled. Maximum to minimum derricking occupies 20 seconds and the slewing arc is 300°. There are six forward speeds and two reverse. Maximum road speed is 15 mph; creep speed is 2 mph. Travel is possible with the full load, overall dimensions with the jib in the travelling position being 14 ft long, 9 ft 4 in high, and 7 ft wide. With a 16 ft jib the crane will lift 3 tons at 7 ft radius, giving a lift of 17 ft under the hook from 4 ft above ground; 1 ton may be lifted at 14 ft 9 in. A 10 ft extension is available. Maximum hoisting speed is 60 ft per min. *Tunny Cranes Limited, Abbey House, Victoria Street, London SW1.*

VERTICAL SCALE THERMOMETERS

Save Space



ACTUATED by mercury in steel, the Model 605 thermometer has vertical scales.

It is claimed that this arrangement results in space saving, as dials at least 4 in in diameter would otherwise be required, and enables comparative readings of a number of temperature points to be made at a glance. The scale is 7½ in long and less than 2 in in width. These dimensions allow a number of thermometers to be housed in a small space, a bank of six measuring 9¾ in deep by 11½ in wide. The thermometer range is within the limits of mercury, being −30° to −1,200°F.

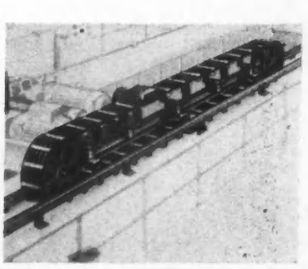
The instrument comprises a coiled alloy steel Bourdon tube, capillary, and temperature-sensitive bulb. The heavy duty Bourdon tube directly drives the indicating pointer, thus, it is claimed, eliminating the backlash sometimes encountered when methods of magnification are used between the tube and the pointer. Scale graduations are linear throughout the range.

The scale has an unbreakable window which is surrounded by a chromium plated flange. Each thermometer is housed in a light alloy casting. Standard finish of the body is hammer grey. Zero adjustment is effected by a readily accessible screw.

Standard length of the copper sheathed capillary is 10 ft; a stainless steel armoury, 6 in long, is provided at the head and bulb. Capillaries up to 120 ft in length can be supplied, with a wide choice of capillary coverings and bulb materials. The standard bulb diameter is ½ in but ⅜ in or ¾ in can be supplied. *British Rototherm Company Limited, Merton Abbey, London SW19.*

CABLE CHAIN

For Connections to Mobile Plant



THE Metool cable chain system has been introduced to handle trailing connections where a multiplicity of electrical conductors or hoses are attached to travelling machinery.

It is claimed for the Metool system that it is space saving, that the flexibles are not subjected to tension, pressure, friction, or other detrimental forces, and that bending falls only within the makers' recommendations. Only a minimum of time is said to be necessary for assembly, and it is stated that maintenance is virtually eliminated. The absence of slip-rings and moving contacts removes possibility of sparking.

The cable chain consists of two roller chains connected by spacers. The flexible elements are housed in holes in these spacers, the centre line of the holes being common to the pitch line of the chain. A stationary terminal box, fitted at the centre of the bottom half of the endless chain (which is also the centre point of travel) is connected to incoming power. Another terminal box is connected to the moving machinery at the centre of the top half of the chain. The upper box can thus move in either direction to a distance equal to approximately twice the overall length of the cable chain unit.

As one-half of the flexibles is passed one way round the chain and one-half the other, the width of the unit is kept to a minimum. While it has been usual to use multi-core cables for such applications, it is claimed that excellent results can be obtained by passing a multiplicity of single conductors through flexible conduits. *Metropolitan Tool and Products Limited, 21 Victoria Street, Nottingham.*

The Decimal-Metric Change in Practice

What will be the effects on industry and the general public if recent moves towards decimal coinage and a change to the metric system are realized?

IN RECENT days the crucial problem of whether to change the monetary and measures systems of the UK to a scale based on factors of ten has, after the customary years of proposal and counter-proposal in the background, burst into a consideration of imminent possibility.

For better or for worse, this country has hung back from acceptance of a regime now in virtually universal usage throughout the world. The pressure of events—amongst which the implications of sharing in the European Common Market must loom large—spotlights Britain's brinkmanship in yet another field. These are closely related questions of alignment in a general scene where it has been slowly, but now urgently, realized that the country may have to deal in equal terms to keep abreast and prosper.

There is a tendency to think that the decimal system of coinage has its roots on the Continent of Europe—particularly in France; but it is revealing to reflect that the British penny was symbolized (*d*) by reference to the denarius (" containing ten "), struck in the Rome of 269 BC with a value of ten asses (about 8*d*); and silver pennies were first issued as the chief coins of England in the 8th century.

The units of the imperial system—which is now threatened with abolition—were fully established in Great Britain in their present form by the Weights and Measures Acts of 1824 and 1878, and today these standards of length, volume and weight are only observed abroad in the domestic systems of the Commonwealth and the USA. France had adopted the metric system in the early 19th century and most other leading countries soon followed suit. Recently, however, the Commonwealth countries have favoured a general switch to decimalization in currency.

In Britain, Royal Commissions in 1838 and 1843 supported decimalization of the coinage, but further Commissions of 1856, 1868 and 1918 all took the view that such a change would unnecessarily disrupt national tradition.

PROPOSALS AND CONVICTIONS

The British Government's present proposals, announced in the House of Commons on 19 December by Mr. Selwyn Lloyd, Chancellor of the Exchequer, are based on the belief that real advantage would follow from adopting a decimal currency. It was realized, however, that the transitional cost for accounting and other monetary machines would be substantial, and a committee was to be set up with Lord Halsbury as chairman " to advise on the most convenient and practical form which a decimal currency might take, including the major and minor units to be adopted; to advise on the timing and phasing of the changeover best calculated to minimize the cost . . ."

An immediate reaction has come from the Association of British Chambers of Commerce (an organization which recommended adoption of decimal coinage 100 years ago) in expressing disappointment that yet another committee was to be created, while they themselves had, jointly with the British Association, advocated the practicability of decimal coinage last year.

For the National Association of British Manufacturers Mr. H. J. Gray stated his full support of the Government's decision: the Association was in favour of decimalization although alive to the complexities of such a changeover. Mr. J. W. Stevenson, general secretary of the National Chamber of Trade, also welcomed the Chancellor's statement.

Conversion to the metric system of measurement and to decimal coinage might well be seen to take place appropriately together, if at all. It is very relevant to take account at this juncture of the opinion of an authority who has evaluated proposals for changing Britain over to the metric system which have been made from time to time since the First World War. The late Dr. H. S. Rowell, writing in ENGINEERING, 8 October, 1948, put his view that: " The unrestricted decimalization that runs through the metric system, although useful for calculations, is not the only evidence of unpractical ideology on the part of its founders. The choice of unit as a decimal submultiple of the earth's perimeter and the decimal derivation of further units with their Greek and Latin polysyllabic denominations bear no direct relation to human needs or faculties. The capacity of the stomach and the size of the hands and feet have brought units into use which are convenient for meat and drink and work. Not even a Continental chemist asks for his liquor in cubic centimetres; and it is a striking fact that, in French and German engineering, the centimetre is never used for the measurement of length."

TODAY'S REACTIONS

What are the views of industrial and scientific bodies on these Government moves? Dr. H. Barrell, superintendent of the Standards Division of the National Physical Laboratory, is all in favour of the trend, both as a scientist and as a citizen. He believes the difficulties of educating the layman are exaggerated, and that future relations with Europe and the emergent countries will demand rationalization. He emphasized that the temperature designation should in fact be expressed as Celsius and not as centigrade—by international agreement (French-speaking countries use " Centigrade " to signify 10^{-4} of a right-angle). The advantage of the °C system was that it was formally defined and related to thermodynamic scales.

For the furnace-manufacturing Birlec division of Associated Electrical Industries Limited, Mr. A. J. Sturrock, development engineer, expressed no strong views about a changeover, but he felt we must remain aware of the USA market and its units. The temperature interest was understandably to the fore here; in any case °C involved conversion for heat transfer calculations usually made in Btu's. Dr. Walshaw of the Birmingham College of Technology, who will be opening a discussion on 5 April, 1962, at the Institution of Mechanical Engineers on " Students' Difficulties with Units in Engineering Science," is keen to abolish the Fahrenheit scale. But he also felt that technical people must be aware of all systems of units—particularly as the USA followed the ft lb sec and ° F practice.

Mr. R. E. Fischbacher, assistant director of the British Scientific Instrument Research Association, was entirely in accord with a metrical changeover—it would obviously take some effort to accommodate it, but the difficulties were overestimated. He felt that temperature measuring instrument companies would welcome rationalization.

A point frequently brought out during such comment is the problem of educating the technical and lay public to a new usage—the average man by this time thoroughly appreciates his room being at 65° F, and the healthy individual is conditioned to his blood being at 98·4° F. One might set against this the difficulties of the cumbersome learning process of school days—at that stage, the collateral assimilation of avoirdupois and decimals can all too vividly be remembered, not to mention the strangeness of counting in " tens and units " as well as in £ *s d*.

END OF THE BEGINNING

For decimal currency, International Computers and Tabulators Limited are avowedly " all set." They are intimately concerned with the outcome of proposals for the introduction of such a system, and plans have already been drawn up for the conversion of data-processing machines in customers' premises.

It was not until 1951 that a definite official pronouncement was made in favour of the metric system in the UK by the Board of Trade Committee on Weights and Measures Legislation (the Hodgson Report)—the recommended change to rationalize the present weights and measures system to be accompanied by a switch to decimal currency. In 1960 the joint report of committees of the British Association for the Advancement of Science and of the Association of British Chambers of Commerce supported decimal currency, but expressed reservations about any change to the metric system on the grounds of impracticability. The Weights and Measures Bill of 1960 offered the first overall legislation in its field since the 1878 Act in the setting up of a permanent Commission on Units and Standards of Measurement, to advise on technical questions and report at least every five years. It sought to simplify British weights and measures, and to modernize the existing systems.

Just as the Fahrenheit temperature scale is commonly met with in countries using foot and pound measurements, it is the rule to use the centigrade or Celsius scale where the metric system is in force. The Celsius designation was accepted by the Ninth General Conference of Weights and Measures in 1948, thus giving formal approval to the fixed points of 0° and 100° as the freezing and boiling temperatures of water, respectively. This decision now tends to outmode the corresponding Réaumur and Fahrenheit limits of 0°-80° and 32°-212°.

In Britain, the recommendations of standardization are to be taken up by the Meteorological Office in 1962 for use in weather reports, and it is expected that Fahrenheit usage will ultimately be displaced altogether by centigrade references for this purpose.

GENERAL IMPLICATIONS

If the UK accepts metrical and decimal systems to the full, the effects on equipment manufacturers and the general public will be far-reaching and profound. It is true that many engineering products are now offered in alternative versions —this has to be the case in order to accommodate both home needs and the export market—and it would doubtlessly simplify production if only one standard system of measurement were necessary. The initial advantages seem to apply primarily to the overseas market approach. For home demand, the conversion of a multiplicity of coin operated machines, of weighing machines and fuel dispensing pumps represents but a small proportion of the plethora of technical problems which would have to be faced. The adaptation of accounting systems and the inuring of the public to a new code of money and measure word values, whilst losing the familiar everyday symbols and their meanings, would constitute an ambitious task indeed and a national upheaval.

The portents of the " rule of ten " may come most strangely with the sudden change in commonplace weights—perhaps because these are more " personal " than even measures of length: certainly of volume—litres and metres have had wide publicity in motoring and sport. It is to be hoped that the gram, which till now may only have been associated with a pill to swallow, may not itself turn out to be the bitterest of all in its wider application.

Such a revolution, though not without its shocks, would most likely only stun quite briefly, the advantages of internal consistency and external conformity being in all probability very real in the long term.

Although the British people may have to do some serious re-thinking before long, they will not be rewarded with a penny for their thoughts —or a pint to drown their sorrows.

Companies

Pace Maintained by Stainless Steel Firm

AN UNCHANGED final dividend of 7½ per cent for the twelve months ended 30 September last has been announced by THOMAS FIRTH AND JOHN BROWN LIMITED, Atlas Works, Sheffield, a firm who specialize in the production of special and stainless steels. Their total dividend for the year 1960-61 will thus be a same again 12½ per cent.

The firm are increasing their allowance for depreciation, charging £869,700 against £733,600 in the previous year. Their debenture interest for 1960-61 is £125,200 against £129,500 previously. After allowing for these charges and crediting investment income and other incoming interest payments, the group's consolidated profit (£4,425,000 in 1960-61 compared with £4,490,000 for the previous twelve months) shows surprisingly little change after what has undoubtedly been a trying year for the steel industry as a whole.

After deducting tax and allocating £537,000 to capital reserves, there remains a net balance of profits amounting to £1,915,000 against a net balance of £1,811,000 for 1959-60. The capital reserves represent additional depreciation and will help the firm to meet the constantly increasing cost of replacing their fixed assets. This year's allocation to capital reserves is £88,000 less than that for 1959-60, which amounted to £625,000.

Although the firm enjoy the benefits of a mixed trade, ranging from heavy castings and forgings to high-grade alloy steels, and although alloy steels frequently forge ahead when other sections of the steel industry tend to lag behind, the company's chairman, Sir John Green, has every cause to be pleased with the progress of Thomas Firth and John Brown.

Courtaulds into Imperial Chemicals

An urgent need to meet foreign competition can be stated as the basic reason for the move now being made to bring about a marriage between IMPERIAL CHEMICAL INDUSTRIES LIMITED and COURTAULDS LIMITED.

If the move comes off, and there appear to be good grounds for expecting that it will, the £208 million net assets of Courtaulds will join the total net assets of ICI amounting to some £695 million to give the Imperial Chemicals-Courtaulds merger a net asset value of around £903 million. Even so, the resulting group will be by no means one of the world's largest, as a comparison of total assets, sales and income with those of such giant organizations as General Motors, Standard Oil, and Royal Dutch-Shell, clearly shows.

In Britain, the man-made fibres industry is divided: Imperial Chemical Industries producing Terylene, Courtaulds making rayon and other artificial fibres, and their jointly-owned subsidiary, BRITISH NYLON SPINNERS LIMITED, manufacturing nylon. This position, as Mr. Paul Chambers, Imperial Chemicals Chairman, pointed out when the proposals were announced, produced serious disadvantages where foreign competition is concerned. It certainly made for a lack of economy, a state of affairs that does not exist in this industry in other countries.

Britain's two largest foreign rivals in this industry, Du Pont in the United States, and Rhone-Poulenc-Rhodiaceta in Europe, both cover the entire field of synthetic fibre production. The duplication of effort in Britain compares unfavourably with the conditions under which these fully-integrated organizations are working.

Research and Development Are Powerful Instruments

Benefits accruing from the merger, Mr. Chambers considered, could include large savings in manufacturing costs, marketing expenses, research and development procedures, and capital expenditure.

Britain's textile industry could retain its position in the forefront of the world's markets as a producer of quality goods. This section was the profitable end of the business. But, the textile industry in Britain could only attain that object if it were well supported by a man-made-fibres industry which was thoroughly integrated and one that constituted thereby a powerful instrument for research and development.

Man-made fibres in all parts of the world had a remarkably high rate of growth. Sales could confidently be expected to rise at a rate of between 10 and 12 per cent a year compound. So far as the European market was concerned, the rate of increase would probably be even more rapid. Whether or not Britain went into the Common Market, British industry could not afford to run any risk of being left behind.

Capital costs involved in the manufacture of these products represented a tremendous proportion of total costs and to continue with existing arrangements, whereby three separate organizations were producing much the same article, involved a great deal of additional and unnecessary expense.

As to creating a monopoly, Mr. Chambers said that if Britain entered the Common Market, "We will not be monopolists in any product I can think of." All their major products were sold all over the world. He found it odd to talk of monopolies because there was so little monopoly privilege at present.

Richard Costain's Lightweight Concrete

Plans have been made by RICHARD COSTAIN LIMITED, London SE1, for expanding the production of Siporex, the Swedish lightweight concrete, in order to satisfy the increasing demands for that product.

Sir Richard Costain, C.B.E., the company's chairman and joint managing director, in reporting this development to his shareholders, states that the results of Costain's new Australian subsidiary, COSTAIN, HANSEN AND YUNCKEN PTY. LIMITED, have justified their expectations. Costains purchased the controlling interest in that subsidiary firm last year.

Preliminary assessments indicate that Costain's contract profits for the first six months of this year were not less than those for the corresponding period last year, but the incidence of higher interest charges following the increase in bank rate in July last, and the effects of the credit squeeze, are beginning to make themselves felt in certain sections of the group's activities, such as house-building.

These aspects, Sir Richard states, will have an adverse effect on the group's trading profits for the second half of this year. The company's directors hope, however, that any reduction in group profit which may be caused thereby will not be such as to necessitate any reduction in the final ordinary dividend from last year's level of 10 per cent. This, with an interim dividend of 6 per cent now being paid, would maintain the total at 16 per cent for the year.

The indications are that turnover for 1962 in respect of the group's two main activities, construction and civil engineering, should show some increase on the results for 1961.

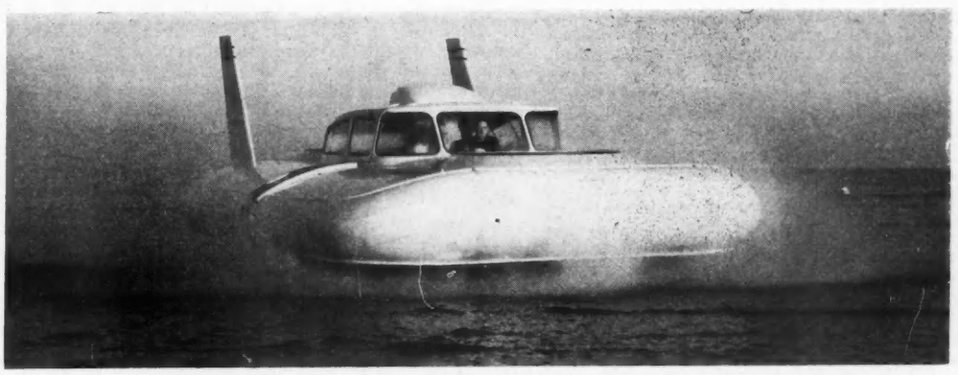
For an account of the first two houses to be built in Edinburgh entirely of Siporex, see ENGNG., 22 Dec. '61 p. 806.

Cushioncraft Purchase by the Ministry of Aviation

Following successful preliminary water trials in the Solent recently, the prototype CC-2 Cushioncraft has been purchased by the Ministry of Aviation. It is understood that this air-riding vehicle, designed and constructed by BRITTEN-NORMAN LIMITED at Bembridge Airport, Isle of Wight, is to be used in connection with a hovercraft research programme at the Royal Aircraft Establishment, Bedford.

The CC-2 vehicle is powered by a Rolls-Royce V8 car-type engine and is capable of accommodating ten passengers. It has proved to be very stable in flight and responsive to its controls. A noteworthy feature is the small amount of light spray which this craft creates when being used over water. It is propelled and steered by thrust from its air-curtain jets; no external propeller being used. It is capable of operating at night and, on its first flight, was driven straight from its hangar into total darkness at three o'clock in the morning.

With a length of 27 ft and a width of 17 ft, the CC-2 has a normal gross weight of 5,500 lb. It hovers at between 12 and 24 in according to the load it is carrying and has a designed maximum speed of around 50 knots, with a range of some 500 miles. In the United Kingdom, its selling price will be less than £20,000.



This CC-2 Cushioncraft vehicle can accommodate ten passengers, has a normal gross weight of 5,500 lb, a designed maximum speed of around 50 knots and a range of 500 miles. It is powered by a Rolls-Royce V8 engine and hovers at between 12 and 24 in, according to its load.

The makers say that this Cushioncraft was constructed as an intermediate-size vehicle in response to requests from potential users who are interested in a relatively cheap amphibious machine.

The Importance of Being Well Designed

Such is the importance attached to the securing of good design characteristics in their products that TURNER AND NEWALL LIMITED, Fountain Street, Manchester, have appointed Mr. E. D. Jefferiss Mathews, O.B.E., a Fellow of the Royal Institute of British Architects, as their consultant architect.

His duties will include advising the company on all matters relating to the design and application of their products for use in the building industry. The group's present range of building manufactures include asbestos cement products by Turners Asbestos Cement Company Limited; plastics products made by BIP Reinforced Products Limited; and stair-treads made by Ferodo Limited.

Increasing attention to design problems will undoubtedly become the rule in ever-enlarging circles of industry as time goes on. Meanwhile, Turner and Newall, with other firms, are blazing a trail to better and better products.

Users' Comment on Steel Cold Extrusions

Comments were invited from several users of steel cold extrusions made by Forgings and Presswork Ltd. In this article, four of them record their experiences and future plans.

AMONG the commercial firms who are showing an interest in steel cold extrusions, Forgings and Presswork are able to list many companies who are actively using or evaluating components made by this process.

This company have ten mechanical presses with ratings between 100 and 1,600 tons which, they say, are intended for manufacture of medium-sized extruded parts up to 18 in long and some 4 in diameter.

The question of where steel cold extrusions are best used is one of some nicety as the company have said "the process is not so often accompanied by such vast savings that it automatically ousts all competitors. . . . Final cost rather than cost of extrusion compared with its equivalent in other semi-finished forms should be considered." This quotation is taken from a contribution by the firm to a conference on the cold extrusion of steel and readers are recommended to see their full comments and subsequent discussion printed in *Sheet Metal Industries*, Jan. 1961, Vol. 38, p. 14 onwards.

The main features of the technique and resulting product are listed by Forgings and Presswork as follows: dimensional accuracy, hence reduced machining; higher strength than normally expected from a given steel specification resulting from cold working; good material economy for the extruders which may lead to extrusions cheaper than other forms; special features on extrusions such as blind splines which are difficult to produce otherwise. More complete information on design factors, tolerances and suitable steels is to be found in the company's recently produced literature.

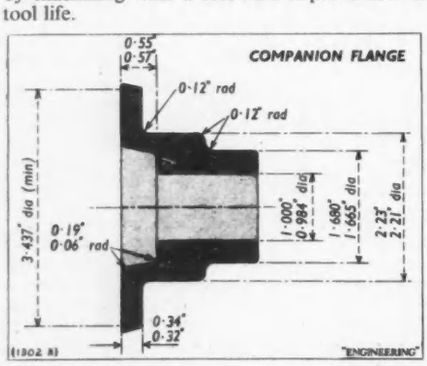
Forgings and Presswork Limited, Birch Road, Witton, Birmingham 6.

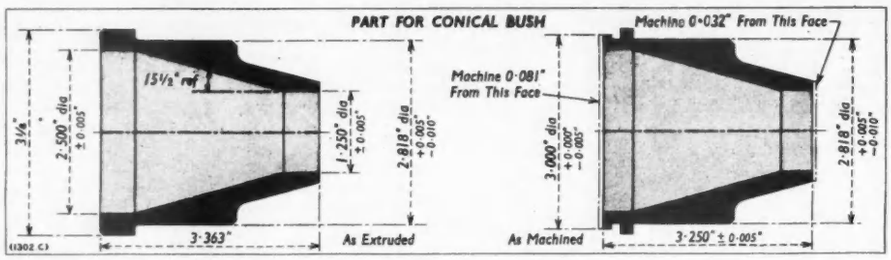
Companion Flange

Salisbury Transmission Limited,
Birch Road,
Witton, Birmingham 6.

Four press operations are needed to produce this component from a billet about 2¾ in diameter by 1·2 in long. It is used for companion flanges and is made in aluminium killed MbK6.

Salisbury Transmission write: "The major advantage of cold forging in this particular application is in the elimination of the first drilling operation, since the forged bore is held to sufficiently close limits to permit broaching the spline. Unfortunately, it is still necessary to machine a substantial portion of the flange, since the hub must be finished to accommodate an oil seal. The greater dimensional accuracy of the cold forging has allowed us to make a substantial reduction in the amount of stock to be removed by machining with a resultant improvement in tool life.





"Although the material [MbK6] is of much lower carbon content than that for the hot forging [En8], the work hardening associated with this process has resulted in comparable physical properties [yield point 30 tons per sq. in minimum]. We do not remove the phosphate layer.

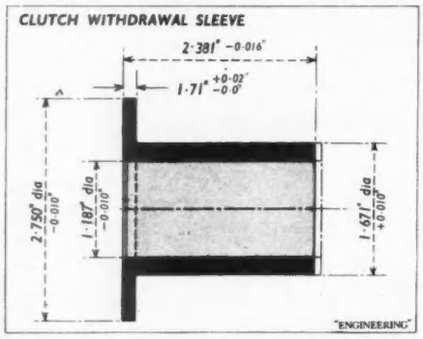
"While the saving on this particular application is quite small, we consider that the proposal is very well worthwhile in order to gain experience, since we anticipate being able to adopt cold extrusion for the production of a wider range of components when we shall be able to design initially with a view to exploiting the advantages of this method."

Clutch Withdrawal Sleeve

Rover Company Limited,
Meteor Works, Solihull,
Warwickshire.

For this user, Forgings and Presswork take En32A billets 2½ in diameter by 0·75 in long and subject them to four press operations.

Rover Company write that this clutch withdrawal sleeve is used on their present vehicles. "The design of this part," they say, "lends itself particularly to the cold forging process of manufacture as it can be made very close to finished drawing size resulting in a saving in machining costs. We have not experienced any difficulty in machining cold extrusions and we have every intention of expanding the use of this process wherever it appears economic to do so."



Outer Part for Conical Bush

Metalastik Limited,
Evington Valley Road,
Leicester.

From billets 3 in diameter and 1·2 in long, five press operations are used by Forgings and Presswork to make this part for a conical bush.

Metalastik write: "The item illustrated is made in ordinary mild steel to specification En2. We have no particular problems as to strength and our sole object in producing this part as a cold forging is in order to save money on machining. You will see that Forgings and Presswork have been able to hold some very close tolerances on the bore and outside diameter, so that machining on these faces is now unnecessary. Prior to using a cold forging, we employed an ordinary hot forging which obviously had to be machined all over.

"Although the respective hot and cold forgings are approximately the same price, the machining cost has been reduced considerably, so that the saving on the finished part is 45 per cent. This item is used in quantities of about 4,000 per year. [Metalastik also say that they produce a similar component only without the machined groove. These are used in similar quantities and they save 49 per cent.] Even on these small quantities we shall be able to recover the tooling cost very rapidly.

"We have not experienced any difficulty with removing the phosphate coating, and find cold extrusions particularly easy to machine. We were under the impression that the amount of cold working which the material receives would cause a degree of work hardening, but this has not proved to be so in practice. We are actively considering other applications."

Steering Knuckle Pilot Sleeve

International Harvester Company (of Great Britain) Limited,
Wheatley Hall Road,
Doncaster, Yorkshire.

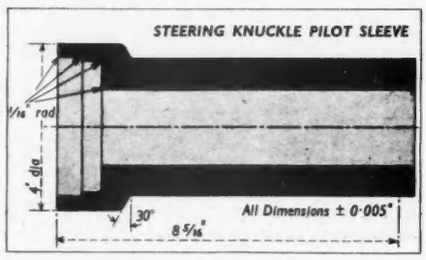
Five press operations are used in producing this steering knuckle pilot sleeve from an En2A billet 3¼ in diameter by 4·8 in long.

International Harvester Company write: "Originally this was made from a tubular forging. Our overall cost saving, including material and manufacture, is estimated to be 30 per cent. An additional benefit is that machining time is reduced by as much as 70 per cent, and the tolerances in the "as received" condition of the sleeve are considerably closer.

"We have found that wheelabrating is sufficient to remove the phosphate coating to prevent any welding problems. This is not an additional operation since it was found to be necessary on the old method of manufacture.

"We have carried out a fairly extensive check on the question of phosphate coating as to whether or not it has any adverse effect on carburizing. So far, our tests indicate that the rate of carburizing is slightly retarded and also a superficial soft skin remains after hardening. These tests have been carried out in anticipation of greater use of cold forged parts which we may subsequently need to carburize. They do not actually apply to the part in question.

"Our annual requirements for the steering knuckle pilot sleeve at present are some 2,000. We feel that there is every possibility of using cold extruded parts much more widely when manufacturing techniques are improved and the full benefits obtainable from the process realized."



Materials for Diaphragm Valves

The makers of Wynn straight-through diaphragm valves claim that they provide superior leak-proof control for hard-to-handle fluids. Since they offer valves in a large number of body, lining and diaphragm materials, they were invited to record their comments on the uses to which the various combinations are put. The following notes were contributed by them.

"The choice of metals, and indeed of all materials of manufacture depends principally upon the nature of the fluid or medium to be handled by the valve, its concentration, temperature, pressure and velocity. The question of the size of the valve also imposes limitations.

"For instance, aluminium to a purity of 99·5 per cent is ideal for handling certain rocket fuels, but mechanically it has limitations, and these will vary according to the design of the valve. We have been able to supply such valves in sizes up to 6 in, which is considered to be a fair achievement.

"At one time we were making valves from a lead-antimony alloy, the only available material to suit a particular duty. This was rapidly superseded by new materials becoming available for lining cast iron valves. This happens constantly, so rapid is the discovery of new materials and methods of using them. We continue to make large numbers of valves in stainless steel, mainly for the food and drinks industry. This is, of course, extremely expensive, but the more expensive the material is, the greater is the incentive to find a substitute.

"The trend is more and more towards the lining of the cheaper materials, such as cast iron, with deposited linings of both metallic and plastics bases. It is not every type of valve that is suitable for lining, but the Wynn valve lends itself naturally to this process, and we confidently expect that the introduction of new and better materials will continue.

"Similarly, great progress is being made with the subject of materials for the diaphragms. The question of strength and flexibility imposes restrictions, so that it is often not possible to use a material that is ideal chemically. To the user, the material need only be suitable for the medium he has to handle, but the other aspects are of essential importance to the valve maker.

"In this regard, the case of ptfe is typical. Chemically it is ideal. It is inert, tasteless and has the most wonderful corrosion and abrasion resistant properties. Its arrival was hailed with enthusiasm by both valve makers and users. We then learned that it is mechanically unsuitable for diaphragms. We also found, of course, that it is very expensive, and so we could not use it indiscriminately. Further, it proved to be almost impossible to bond it satisfactorily to any other suitable diaphragm material.

"A very great deal of research has gone on since then and we had begun to think the problem insoluble, when our collaborators in the USA came along with an entirely new approach to the problem. This is now being worked upon, and we have good hope of a great measure of success in the fairly near future."

Wynn (Valves) Limited, Granville Street, Birmingham 1.

Solid Tantalum Capacitors

The Kemet Division of Union Carbide are now marketing an extensive range of solid tantalum capacitors. The capacitors currently in use in the United Kingdom are mainly the foil and wet electrolytic types, each of which can now be replaced by solid tantalum capacitors with considerable advantages in space, weight and reliability, according to the makers.

The Kemet Division of the Union Carbide Corporation say that they have had considerable experience in the development and production of these solid sintered slugs, which satisfy and exceed the demands of US Military Specification MIL-C-26655A. The products are claimed to offer good reliability, the failure rate being in the region of 0·02 per cent per 1,000 hours.

Solid tantalum capacitors made by Union Carbide are manufactured in four case sizes, providing thirty values from 0·0047 to 330 microfarads and a voltage range of 6 to 75 volts. These capacitors are currently made in the United States, but Union Carbide say that production should begin in early summer, 1962, at the Aycliffe, County Durham, factory in the United Kingdom.

Union Carbide Limited, 8 Grafton Street, London W1.

Slotted Angle Accessories

Items of shelving accessories are being introduced by Dexion which, they say, make their racking system considerably more comprehensive and flexible.

The accessories will make it possible to have various types of storage bay within any given run of Dexion steel shelf racking. Also, existing

structures can be converted either wholly or in part to closed-type racking without costly replacement or dismantling.

Referring to letters on the illustration, the new range consists of: A, steel cladding sheets used as backs and sides to Dexion racking; B, divider clips to clip on to the front and back edges of the shelves; C, steel dividers for sub-dividing Dexion shelves to store small components; and D, card holders which bolt to the front or back of any Dexion shelf to hold cards for identification or pricing.

Dexion Limited, Maygrove Road, London NW6.

Flexible Joint for Stoneware Pipes

A flexible joint known as Drawflex, made by Doulton and Company, is claimed by the makers to enable salt-glazed vitrified pipes to be securely and permanently connected without the use of cement either for jointing or bedding. At the present time it is limited to pipes of 4 to 9 in diameter. It will be in production early in 1961.

Doulton comment that the system enables each joint to flex freely in any direction to a maximum angle of 5° and be telescoped or drawn by as much as ¾ in while withstanding satisfactorily an internal or external pressure of 20 lb per sq. in, the equivalent of a 43 ft head.

Drawflex joints are made by pushing the spigot into the socket with the aid of soapy water as a lubricant. The sealing element is made in plasticized pvc which is moulded on to the spigot and to the annulus of the socket. According to Doulton, the design is such that a compression is built up between the two seals, with a special high-compression zone in the centre. The plastic material is resistant to chemicals normally found in effluents, sewage or soil, and to bacteria and root penetration.

Drawflex joints can be disconnected for repair and salvage work. The makers report that the product has been tested by the Building Research Station where stringent tests have resulted in a very satisfactory report. Arising from this, they add, the Ministry of Housing and Local Government have approved the use of the joint on stoneware pipes from 4 to 9 in diameter, stating that the joint will qualify for a maximum loan repayment period of 30 years.

Doulton Vitrified Pipes Limited, Doulton House, London SE1.

Link Matting on Tanker Bridge

Shropshire-made fibre rubber marine link matting has been fitted on the Shell tanker s.s. Sepia. The 1,600 sq. ft of matting was tailored to fit round the various bridge instruments in the wheelhouse and bridge wing decks. The matting was produced by Nuway Manufacturing Company.

In heavy seas, comment this company, the serrated fibre surface of the matting ensures that the bridge personnel are less likely to slip and lose their footing. In addition the open link structure allows the deck to dry out quickly.

Nuway Engineering Company Limited, Coalport, Shropshire.

Casting Resins for Electronics

Under their agreement with Emerson and Cuming Inc. of America to market in the UK plastics and ceramic materials designed for the electronics industry, the electronics division of Microcell Limited can now supply two new casting resins, Stycast TPM6 and Stycast 1223.

An easy-to-use casting resin, Stycast TPM6 is a cross-linked polyethylene type formulation which is economical, easily machined and possesses excellent electrical and physical properties, according to Microcell. It is suitable as an encapsulant and sealant in a variety of radio frequency and microwave applications. Stycast TPM6 can also be used as a direct substitute for polyethylene in cables, connectors, insulators and transmission lines. Microcell add that it will not cold flow, has a temperature capability which exceeds that of polyethylene by about 200° F, and has better thermal dimensional stability and is far cheaper than ptfe. No catalyst is required and it can be mixed and poured from its own container.

Stycast 1223 is a general two-part formulation which is said to flow easily making it suitable as an impregnant in many applications.

Microcell Limited, 9 Kingsway, London WC2.

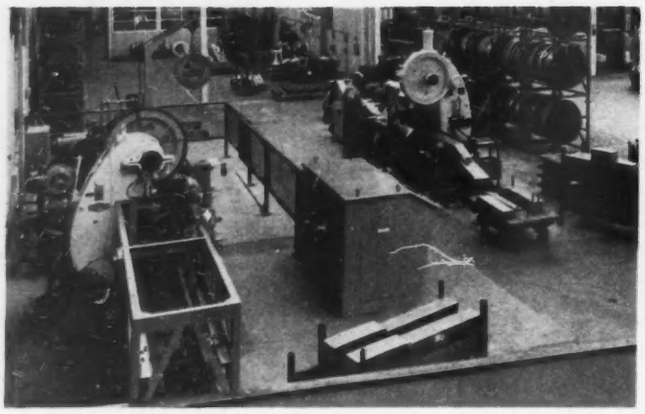


Fig. 1 The two automatic feed lines for producing transformer core laminations. The newer, faster line is on the left, with the final stacking unit in the foreground.

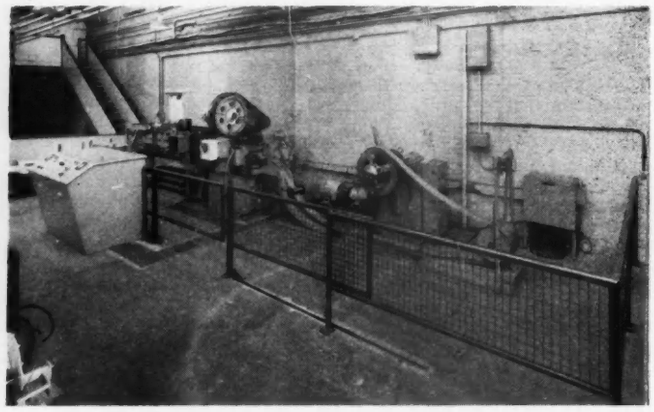


Fig. 2 A side view of the more recent feed and cropping line. On the right is the loop control arrangement and on the left the measuring control panel.

Development of an Automatic Feed Line

Since cold rolled steels became available in continuous strip form, the logical next step has been to develop automatic methods of feeding and cutting the coils. Such methods have been developed in two stages in the manufacture of transformer core laminations.

Progress in production engineering tends to be a relentless leapfrogging and interaction between related manufacturing processes. When, for example, production of cold rolled grain-oriented steels in continuous coils became practicable, industry was then confronted with the necessity for utilizing this new type and form of steel by engineering ways of feeding and cutting the coils automatically. This problem has been met in two stages at Ferranti's West Gorton, Manchester, factory in the manufacture of laminations for distribution transformer cores.

In this particular application, conventional guillotining methods were too slow, inaccurate and wasteful for Ferranti's needs, and serious handling difficulties were presented by the coils, some of which weigh nearly 1½ tons. By 1958, therefore, a pilot automatic line was introduced with plant installed by the BHP Machine Tool Company, of Birmingham. This first automatic line, which is shown on the right in Fig. 1 above, can feed material with consistent accuracy to within 0·015 in in length; can be reset quickly from one length to another within the range 3⅞ in to 41½ in; provides a feed rate of 40 ft per minute; and can handle material from 1½ in to approximately 8½ in wide.

This feed line has a motorized roller feed and is controlled electronically using magnetic clutches and brakes. The component parts of the line include a BHP decoiling unit and feeding machine: combined press and cropping tool; a control panel on which the length of feed is preset; a Ferranti lamination dispenser unit; and a batch counter which automatically switches off the line when the specified number of laminations has been produced.

Thus, the development work in this first feed line was basically a matter of combining individual—and, usually, proven—units. Under the second stage of development, however, there is now a further automatic feed line which is completely integrated and operates at more than 120 ft per minute—that is, three times as fast as the pilot line. This second line—which is shown in the left in Fig. 1 and in side view in Fig. 2—cuts more positively and accurately than the pilot line, and involves less changeover and set up time. It is used in the manufacture of conventional core and mitred core laminations, and was designed and manufactured by Humphris and Sons, of Poole, Dorset.

The principal elements in this integrated line are a decoiler; a control cabinet; a loop control unit, incorporating a photo-electric cell; a loop support unit; a feeding and measuring mechanism, incorporating pinch rolls, measuring rollers, and entry and exit guides; a Humphris CP25 Pressmaster open front power press with an oscillating mitre cutting tool; and a run-out table and stacking unit for the finished laminations. An interesting feature of the oscillating press tool, which has tungsten carbide shear blades, is that air flotation is used in obtaining free angular movement through 90° to make alternate 45° mitre cuts.

The arrangement of units is broadly similar in the pilot line and in the integrated line but one of the differences between them lies in the method of cutting the strip to length. In the original line, a perforated 12 in diameter disc with 120 divisions is mounted at one end of the combined feeding and measuring rollers. The rotating disc interrupts a light beam from a photo-electric cell and actuates counters on the control panel, the smallest measurable interruption being equivalent to the feeding of 0·015 in of strip. In the newer line with its greater throughput, quicker and more accurate setting of length, and closer consistent accuracy—a different method of length measurement has been used. A position control servo system (for which patents are pending) has been developed jointly by Humphris and Sons and by Laurence, Scott and Electromotors, of Norwich.

THE INTEGRATED PROCESS

When setting up the line, a special loading truck (which can be seen handling a coil in Fig. 1) is used to load coils on to the decoiler. The latter consists of a spindle-mounted mandrel driven by a variable speed ac motor through a reduction gear and electro-magnetic clutch with an electro-magnetic brake at the other end to control overrun. Material is then inched from the coil and threaded beneath the "no loop" control arm into the feeding machine pinch rollers and between the side guides.

The motorized reel is then switched to automatic operation and the maximum reserve loop of material formed, the reel being stopped automatically at this point when the control unit is actuated by its photo-electric cell. Next, the measuring rollers of the feeding machine are engaged and the specified strip length is selected on the control panel.

Once set up, the automatic sequence of operations begins with the strip being drawn from the loop by the feed rolls—powered by a 3 hp dc motor—and passed through a pair of measuring rollers before being fed into the cropping machine. Though the average rate of this feed action is 120 ft per minute (this must vary, of course, with the required frequency of cropping) it has sometimes been raised as high as 200 ft per minute with suitable material and in suitable operating conditions. The dc motor on the feed rolls is part of a Ward Leonard system, a dc amplifier providing the field for a split field generator driven by an ac induction motor. In turn, the generator feeds the dc motor armature—the field of which is fed from a separate dc source—and the motor drives the feeding machine rollers through a step-down gearbox.

The measuring rollers through which the strip passes drive a two-lift cam through a reduction gearbox and reversing clutches, and the lifts on the cam rotate a magslip, the lifts being designed so that at some point zero output is obtained from the magslip rotor. Output from the rotor is then fed into a phase sensitive rectifier. Thus, rotation of the cam about this point of zero output will give a positive or negative output from the phase sensitive rectifier and, as this is fed into the dc amplifier, the system forms an accurate position control servo.

Once the dc motor is running, it continues until the cam rotates the magslip to give zero output. The cropping tool is then operated, the clutches reverse and the cam is driven in the opposite direction as the sheet or strip moves forward until stopped by the other lift rotating the magslip to give zero output. It is, of course, the adjustable distance between the lifts which gives the length of material cut.

After cropping, the core laminations are carried forward to a stacking unit (in the left foreground in Fig. 1) by a continuously driven conveyor belt. The run-out table for the cut material consists of two hinged doors, operated pneumatically, which discharge the laminations on to a pallet. Opening of the doors is actuated by a micro switch as each lamination is delivered from the conveyor belt, and a second micro switch closes the doors again after the laminations have been discharged.

This newer automatic feed line is 30 ft long by 9 ft wide and can be handled by a single operator. The laminations cut in this particular process vary in length from 3¾ in to 72 in; in width from 1½ in to 10 in; and in thickness from 0·012 in to 0·014 in. Average outputs attained have been 20 strips per minute for 72 in lengths and 30 strips per minute for 36 in lengths. Initial setting up takes 10 minutes and coil loading time is approximately 3 minutes. The heaviest coils used have weighed about 2,800 lb and they have been up to 44 in in outside diameter.

Ferranti Limited, Hollingwood, Lancashire.

Aluminizing Exhaust and Inlet Valves

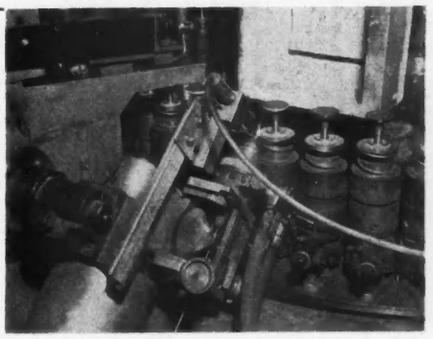
The 1962 Vauxhall models will be the first British cars to have aluminized exhaust valves. Using a process developed in the USA by General Motors, the heat-resisting steel valve seat on the valve head is sprayed, when pre-heated, with melted aluminium which, after further heat treatment, forms a tough layer with the valve steel. In this way, the valve seat, as it makes contact with the cylinder block during each cycle, is able to take away by conduction the intense heat—around 650°C—developed in modern engines using present-day fuels. Vauxhall's are also aluminizing their inlet valves for the same purpose.

Integrated with the existing production plant, the equipment for the process has been supplied by the Lindbergh Company of Chicago, USA. Basically, the equipment consists of a motorized turn-table conveyor 5 ft in diameter and having a number of fixtures around its perimeter to hold the components. Positioned outside the turn-table are a pre-heating unit; a flame metallization unit; a re-heat unit; a cleaning unit; a cooling unit; a dust extraction plant; control panels and control gear; and materials handling and inspection arrangements. The table is driven by a ½ hp electric motor.

After being lowered in basket loads into the degrease tank, components are delivered by band conveyor to the loading station. Loading is manual, the components being loaded head uppermost into 46 cylindrical collet-fixtures spaced 4 in apart around the turn-table. To make for interchangeability between the five types of valve processed, the fixtures have clamp type chucks which engage automatically after loading.

Each fixture has induction coils and a central spindle which rotates the valves at precisely the required speed. This spindle extends downwards beneath the table and is driven by a spur gear wheel. As the fixture enters the pre-heat station, the spur gear engages in the grooves of a length of hard rubber belt, electrical contacts are made through the induction unit electrodes and the component is heated in a few seconds to approximately 260°C. Next, the valve enters the flame metallization station where a metal spray gun (shown in the illustration) is mounted on the table framework and can be adjusted to the correct height and angle for spraying the seat of each valve type.

A high purity 17 gauge aluminium wire is used as the aluminium source. Its rigid specification demands that it is 99 per cent pure, strain hardened, free from kinks, and clean. The wire is mounted on a horizontal reel and is pulled through the spray gun by a small electric motor. Oxygen is fed to the gun at a pressure of 48 lb per sq. in and propane at 16 lb per sq. in.



A close-up of the spray station. The components are passing from right to left.

At the next station, a re-heat of about 800°C is applied through the induction coils and the component is ejected down a chute on to a band conveyor which has an air cooling system. Inspection is visual and by weight differential, the deposit of aluminium varying between 0·05 grammes and 0·07 grammes according to the type and size of valve head.

Vauxhall Motors Limited, Luton, Bedfordshire.

Proof of the Pudding in Planning and Control

Production planning and control are probably at their most complicated and necessary in the motor industry. Any advance in production planning techniques (any new method of getting components to the right place at the right time, keeping the production lines moving, but without cluttering the production floors with work-in-progress) is therefore a major event in the industry.

Such a major event is the fact that over 250,000 Austin A40 and Austin Mini bodies have now been trimmed and finished on a new system of "marshalling" at the Longbridge Works of the British Motor Corporation.

Marshalling is the name given to the process of ensuring that all components and materials—in this case, the front and rear screens, quarter lights, bumpers, lamps, instrument panels, carpets and other items—are at the right point on the main assembly line at the right time.

Previously, before the installation of the new system in March, 1959, it had been the general practice to bring all these components from the stores by truck and place them in pallets beside the assembly line—a procedure known as "track-side marshalling."

In the new system, a separate conveyor at floor level moves alongside the assembly line, at the same speed, bearing two trucks of components for each car body. Each pair of trucks contains all that is needed to convert the painted car body shell into a finished body complete with glass, trim and chromium-plated accessories, ready for final car assembly. The trucks, of course, are loaded in the stores, so that the operator on the line finds everything to hand.

Since this installation was introduced to the car assembly building at Longbridge—at a cost of £350,000—just over two and a half years ago, it has been so successful that the No. 2 car assembly building, which will be ready next August, is to have a similar installation.

The advantages of the system can be summarized as (*a*) it has given a saving of hundreds of pounds a week in reductions of damage to parts; (*b*) less storage space is required on the actual factory floor; (*c*) greater flexibility is provided, so that the main assembly line can switch more easily to other models in the event of a shortage of certain supplies or of changed customer demand; (*d*) the operator's job is made easier from the method study angle; (*e*) it makes for better stock control; and (*f*) it makes good shop-floor "housekeeping" easier.

The British Motor Corporation Limited, Longbridge, Birmingham.

Automatic Tube Filling Equipment

Arenco have introduced a fully automatic version of the already widely used GAB tube filling machine. This new model, which is shown in the illustration on the right, has photo-cell registration and automatic feed and gives an output of 60 tubes per minute compared with the 45 given by the earlier model.

It will handle a wide variety of tubes and materials and can be used for portioning and filling such materials as pastes, creams and liquids with viscosities ranging from that of water to very heavy pastes, without in any way interfering with that viscosity. The original consistency of the material being processed is maintained by a stirring device incorporated in the hopper and by the fact that the hopper has a water jacket with thermostatically controlled electric heating.

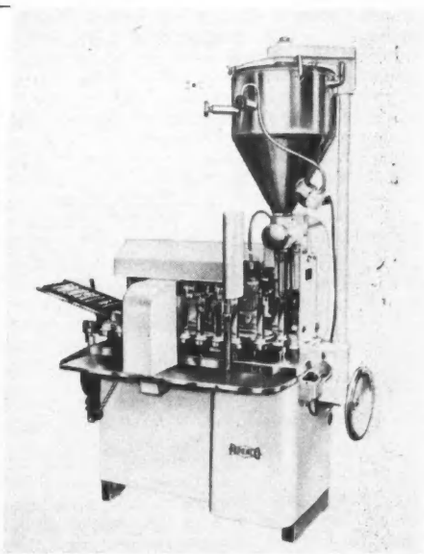
In its standard form the machine will fill tubes of up to 1½ in diameter and up to 7¼ in in length. Adaptations can be made to handle larger tubes of up to 1¾ in in diameter and 8 in length—the changeover time being a matter of a few minutes only—and a special pump can be fitted for filling very small tubes of, say, 1 cc capacity. Adaptations can also be made quickly for the filling of jars, vials and cartridges.

In operation, tubes are placed on the in-feed tray and then fed automatically into the tube holders where the photo-cell registration device turns them so that the printed surfaces are the right way up. Filling is by the "drop-away" system in which the empty tube is raised almost to the filling nozzle and then, as the filling cycle begins, progressively dropped away until filling has been completed.

This system ensures that no air is mingled with the paste or trapped during the filling cycle, and it also guarantees exact filling height and a clean closure. Closing can be to any desired folding pattern, with or without crimping, and coding on the closure and final discharge can also be arranged to suit any cartonning.

One operator only is required and each machine can be expected to turn out consistent outputs of up to 3,600 tubes per hour. The manufacturers have in mind such widely different materials for packing as tooth paste, shaving cream, cold cream, shoe polish, artists' colours and paints, adhesives, penicillin, caviare, food paste, mayonnaise, mustard, cream and fluids. A mixed bag—or, rather, tube—indeed.

Arenco-Alite Limited, Pixmore Avenue, Letchworth, Hertfordshire.



The new Arenco GAB fully automatic tube filling machine. Paste is delivered from the hopper and tubes from the in-feed tray on the left.

On the Shelf

By Frank H. Smith

THE other evening young Nigel (12—grammar school) was doing his homework when he said "Listen to this Dad, 'For reconstructions of Caerwent and Wroxeter see *The Illustrated London News* for 18 March 1939 and 9 September 1925'—what a hope." If such a reference strikes a youngster as being ridiculous one wonders how it could get into *This England* in Macmillan's Junior Histories series, published in 1960. When he had gone to bed I had a better look at the book and it was peppered with references to previous pages. I wonder if there is scope for an advisory panel of librarians to instruct schoolbook writers how to maintain a reader's interest? Such hoppings back and forth completely destroy continuity of interest.

One of my newshounds (the chief one, actually) tells me that the University of Sheffield is considering starting a school of librarianship. Which reminds me that one of my scientifically trained librarian friends has stopped his technical library staff coping with such queries as timetables, where to buy pâté de foie gras, what's a copita and so on. He feels it engenders in people a tendency to regard the library staff as dogsbodies.

I fail, utterly, to understand the fascination of aeroplanes. They leave me stone cold. Yet two publishers, Putnam and Macdonald, seem to make a very good thing out of them and Macdonald's latest catalogue (16 Maddox Street, London W1) lists seven new books plus one on the Glider Pilot Regiment. It beats me.

Unusually informative booklets come from Blackwell's of Oxford. Two, under the general heading "New and Forthcoming Books" are devoted respectively to "Technical" and "Science and Mathematics" for autumn, 1961, and besides title, author and price (or probable price) give a two or three line gist of the matter covered. A third is Catalogue 760(5) 1961–2 and is titled "Science, Mathematical, Physical, Biological". I feel that Julian B. should give, somewhere inside, a little credit to the artist responsible for the delightful Oxford scene on the front cover. This particular catalogue is, apparently, books in stock. It is subject-divided.

Strictly utility and unaesthetic is *Silicate News* from Link Information Services, Orchard House, Orchard Street, London W1, but sponsored by Joseph Crosfield and Sons Limited. A quarterly abstract bulletin, it aims to cover silicate news here and abroad. It's free.

I've referred before to the varied interests catered for by the United States Government Printing Office whose material is obtainable through HM Stationery Office. The latest list gives some items published for the Smithsonian Institution's Museum of History and Technology, one of which is *Introduction of the Locomotive Safety Truck* (a brief résumé of its development during the 19th c.). The catalogue number is SI 3.3:228/paper 24; price 20 cents.

Any public librarian who happens to read this and who also has had an inquiry on how to make a steel band (the sort that calypso players use—made from oil drums) will get the information he wants from *Steel Review* No. 24 (British Iron and Steel Federation, Steel House, Tothill Street, London SW1). I like to imagine the staff of BISF practising at the nearby Central Hall, Westminster.

The message is so unusual these days that I feel I must mention the letter that *Keesing's Contemporary Archives* are sending out with renewal notices. ". . . the subscription rate will again be maintained at the established level." This level was fixed in January, 1956, since when the average cost of printing has risen by 39 per cent. One could argue, of course, that their rate at that date must have been pretty high but that would be ungracious. Funny thing—economics.

Designing Core Cross-Sections

Fast Reactor Cross Sections: A Study Leading to a 16 Group Set. By S. YIFTAH, D. OKRENT and P. A. MOLDAUER. *Pergamon Press.* (35*s*)

"Something for nothing" has attractions for us all and the idea of the fast breeder reactor, producing more fuel than it consumes, appealed strongly to this instinct. By concentrating on this aspect of the fast reactor and ignoring the great technical difficulties presented by the high power density in the reactor core and the necessity to use a liquid metal coolant for heat removal, an unrealistic, almost emotional, attitude to it was developed. Inevitably, as a result of the delays and difficulties at Dounreay, this initial over-enthusiasm has been followed by a period of great pessimism in which the fast reactor project has been widely regarded as a costly folly to be abandoned as soon as possible.

A more balanced view has at last been established. The Dounreay project is properly called a reactor experiment and is regarded as but one of several possible systems which may reduce the cost of nuclear power generation and provide a method for using the by-product plutonium from graphite or water-moderated thermal neutron reactors. Until operating experience has been gained it will not be possible to make proper estimates of the generating costs of a full-scale system. Such a reactor will almost certainly be shown to be technically feasible; whether it is economically acceptable is more open to doubt.

As with all power reactors, the bulk of the problems are those of engineering design. Nevertheless, solutions of problems arising from the behaviour of reactor materials and a detailed knowledge of the reactor physics of the system are essential to a successful design. The reactor physics problems associated with fast reactors are very different from those of thermal reactors. Because of the relatively small cross-sections of the core materials at high neutron energies the heterogeneity effects associated with thermal reactors are largely absent; however, significant neutron interactions (inelastic scattering, for example, as well as absorption) take place over a wide range of neutron energies instead of being mainly confined to a narrow energy band. By using digital computers the problems of neutron slowing down and diffusion and of core geometry can be solved with multigroup programmes, provided that the appropriate neutron cross-sections are known.

The purpose of this volume is to construct a self-consistent multigroup set (16 neutron energy groups) of effective cross-sections. The derivation of this set from basic data is described in great detail, full references being given to all sources of information and a careful analysis being made of errors. New information can thus be readily included as it arises. An analysis is made of the regions in which further experimental work is needed and a comparison is made between the predicitons of the multigroup data and the results from experimental fast reactor systems. This is probably the first well documented analysis of fast reactor cross-section data which has been made without empirical adjustments and should be of great value to those working in the field of the physics of fast reactors.

Fast Reactor Cross Sections is, unfortunately, of little use to the general reader because of its extreme specialization, although the work itself and its presentation are admirable. One wonders why it has appeared as a book at all; the number of people working in the fast reactor field and having access to large digital computers must be so small that private circulation or publication as an official report would surely have been adequate.

P. J. GRANT

Lighter Gears—Heavier Loads

Increasing the Loading on Gearing and Decreasing its Weight. Edited by M. M. SAVERIN. *Pergamon Press.* (70*s*)

This book is a collection of eight translated Russian technical papers on subjects relating to gears and gear units; some interesting details are given on driving gears for a 720 mm continuous billet mill, together with the actual load transmitted and the number of running hours accomplished in service, some of the units having run as much as 72,000 hours. Similar details are given for units driving slabbing shears. The condition of each of the units after the number of running hours stated is given for reference.

Tooth load is based on formulae evolved by the Tsniitmash Laboratories which take into account separately the load capacity based on the strength of the gears and secondly the surface loading of the teeth. There is a report on this subject—Scientific Technical Information No. 23, Mashgiz 1954, which was based on tests of gears with different surface loads.

There is an analysis of the details of service accomplished in connection with reduction gears for a 3-stand tandem type 1,680 mm continuous strip mill—cold rolling.

A study is outlined of the proportion of facewidth to centre distance for gears of different ratios indicating which are of the most economical proportions; the ratio of facewidth and centre distance is usually governed by deflection of the pinion and the practice followed does not differ greatly from that adopted in the United Kingdom.

Various tables are given and one table indicates the practice of David Brown Industries in this connection. Formulae are given for the weight of gear units, but these are naturally of a rather complicated nature.

Rules are given for thickness of casing and covers, shape of flanges, diameter of bolts and other details, and suggested proportions are given for cast steel gear wheels and for gears with forged steel rims shrunk on cast iron centres and also for gears constructed with rims bolted on centres, but no reference is made to the welding of gear wheels and cases, a practice commonly used in this country.

Attention is paid to the question of equivalent loading for gears subject to variable loads, referred to briefly as the summation of fatigue.

The metallurgical structure of steel is considered and it is mentioned that fatigue failure begins when even a small fraction of the grains or crystals become deformed.

The question of work hardening is dealt with as well as the advantage of running in gears on light load so as to remove high points which are liable to give rise to local concentration of stresses.

The question of addendum modification is dealt with in a special case in which the wheel is all addendum and the pinion all dedendum; it is pointed out that this can only be adopted when the number of teeth in the pinion is large; the term "profile displacement" is used, a term the equivalent of which is favoured in some other countries and by some investigators in this country. The treatment of this particular subject is largely theoretical, but there is a reference to some tests. It is claimed that the use of an all-addendum wheel makes the best use of the tooth material and gives the highest load capacity.

Photographic illustrations are given showing the condition of teeth after a period of running; in one case where extensive pitting has taken place near the tip of the tooth, it gives the impression that there might have been a slight

error in tooth profile which would detract from the value of the tests. After examining the test results it is stated that the practical value of an all-addendum wheel does not come up to the expected value and that the high sliding speed may cause excessive wear of the teeth.

It was found that frictional losses in a reduction gear unit with an all-addendum wheel were of the order of 2 to 2·2 per cent including bearing losses and resistance to lubricating oil. The power loss in the gears themselves as regards friction between the teeth only is 1 to 1·2 per cent; this value tends to be higher than what has been measured in this country for gears of normal proportions, but perhaps this is to be expected by the greater amount of sliding involved.

A second paper on the same subject is given by other authors who disagree with the previous one; the opinion is expressed that an increase in load capacity could have been obtained with increased hardness of pinion, which of course is to be expected; this paper concludes that there is an increase in load capacity of about 40 per cent, but disagreement is expressed with the conclusion of other Russian investigators who have claimed as high as 300 per cent.

There is an interesting section on the subject of dynamic loads, although a caution is given that the data obtained is not sufficiently reliable to be used for load capacity calculations. All effective errors can be reduced to a single error, but no account is taken of attached masses or elasticity and shafts.

Reference is made to work done by Earle Buckingham on this subject but the writers are not convinced that Buckingham's conclusions are acceptable. They mention that errors in Buckingham's work were pointed out by Petrusevich who also himself made a mistake in drawing his own conclusions. The discrepancy in theoretical as compared with experimental values of dynamic load is explained by the assertion that in tip meshing the effect of errors is reduced to some extent by contact deformation, and it is pointed out that tip relief will give absence of load concentration at the tips. The general conclusion is reached that further study is required on the subject of dynamic loads resulting from manufacturing errors, with due consideration for attached masses and rigidity of shafts.

The last paper in the series refers to experimental determination of tooth rigidity in cylindrical spur gears and concludes that the elastic displacement is directly proportional to the load, is dependent on the pressure angle and the rigidity of the rim and is independent of the pitch of the gear.

The book is worthy of the study of those engaged in the design of reducing gears, particularly for rolling mill drives.

A. SYKES

Modern View of Entropy

The Third Law of Thermodynamics. By J. WILKS. *Oxford University Press.* (15*s*)

It can be assumed that when Clausius introduced into the heat machines theory the concept of entropy, he did not expect that it would secure so great a place not only in physics, but, more generally, in human thought. This success is attributed by Eddington to the fact that entropy " was in great favour with the engineers. Their sponsorship was the highest testimonial to its good character; because at that time it was the general assumption that the Creation was the work of an engineer (not of a mathematician, as is the fashion nowadays)".

But, as a matter of fact, nowadays entropy does no longer remain in the hands of engineers; mathematicians seized it, and thus its " good character " even now cannot be suspected. It must however be added that this new sponsorship is by no means gratuitous. Engineers were satisfied with the whole, or macroscopic, sight of entropy, which has a precise physical meaning (even if this is not always seen very clearly), but does not involve a subtle mathematical treatment. Mathematicians, on the contrary, are mainly interested in the inward, or microscopic, sight of this quality, which implies the use of statistical mechanics and wave mechanics, and these mathematical tools may be beyond the scope of knowledge of the average engineer. It is necessary to keep the distinction in mind before reading J. Wilks' book on the Third Law.

At present time there are four laws of thermodynamics. The " zeroth " law deals with thermal equilibrium, the first law states the equivalence of heat and work, the second law deals with changes of entropy and, finally, the third law assigns to entropy an absolute value. Before discussing the third law the author develops the relation between the concepts of entropy as used in thermodynamics and in statistical mechanics and shows how the components of a simple system may contribute to its entropy. That leads him to consider, among other questions, the entropy of mixing of perfect gases. He applies the usual method of semi-permeable membranes and thus arrives inevitably to the well known Gibbs' paradox; but he dismisses it by putting forward " the impossibility of obtaining a semi-permeable membrane to distinguish between two identical gases." But actually it is also impossible to obtain such a membrane for two different gases and thus the distinction between the two cases seems to be artificial. Of course, as the author points it out, in the case of different gases such membranes are quite feasible " in principle "; but so are also Maxwell's demons and similar devices, nevertheless the results obtained by such means are usually considered as mere curiosities, not as scientific facts.

The third law was put forward by Nernst; although the author does not describe the early history of this law, it is surprising that Planck's name should be mentioned only in connection with the radiation law, as his contribution to the final form of the third law was essential (1911). But the discussion of this law in the book is excellent and well abreast with the present state of the question. The author considers first the application of the law to some simple systems in complete internal equilibrium and shows that in this case, according to the third law, the entropy of the system tends to zero at absolute zero. Interesting illustrations of the law in such cases are the entropy of allotropic solids and the superconductivity of metals in the neighbourhood of absolute zero; another example is the behaviour of two isotopes of helium in liquid state. Then follows a discussion of more complex systems where at least one aspect is not in equilibrium, an " aspect " being one of the various modes in which the entropy of the system may arise. A detailed study of statistics of a perfect gas (the Bose-Einstein and the Fermi-Dirac distribution functions) precedes a discussion of the statistical basis of the third law as applied to real systems. The author also studies the behaviour of the entropy arising from several nuclear aspects of a system, such as magnetic moments or mixing of isotopes and, after that, applies the third law to the determination of equilibrium constants of chemical reactions. The last chapter is one of the most interesting, as it deals with the unattainability of absolute zero, the negative temperatures and the different formulations of the third law.

The author is an university demonstrator in physics and his book is obviously addressed to physicists. But it should also appeal to all those who wish to keep themselves acquainted with the basic principles of modern thermodynamics, or with the present ideas about the very low temperatures. The book is well produced and is provided with a bibliography and with a subject index. It can be the more recommended as there are very few works upon the last but not least law of thermodynamics.

P. CHAMBADAL

Keeping Equipment Working

Electronic Maintainability. Volume 3. Edited by F. L. ANKENBRANDT. *Engineering Publishers, Elizabeth, New Jersey. Distributed by Reinhold, New York; Chapman and Hall, London.* (80*s*)

This book consists of a series of papers read at the third Electronic Industries Association Conference on Maintainability of Electronic Equipment held in San Antonio, Texas, USA. The date of the conference is not given, but the book was published in 1960, so that the information is between one and two years old. However, this is not necessarily detrimental as most of the papers describe maintenance approaches which do not " date."

There are two schools of thought in this country concerning maintenance of electronic equipment—those who consider that " design " is all important, including redundancy techniques to reduce maintenance, and those who consider that equipment is so complex that first class maintenance is the only satisfactory way to keep equipments running. This book is addressed to the latter and certainly succeeds in presenting a picture of the American scene in this field. The papers, naturally, range over a wide field commencing with three " keynote " papers covering the Army, Navy and Air Forces' outlook on maintainability. The remaining 25 papers cover every aspect of maintenance, both theoretical and practical. They include management cost, and design as well as organization and training.

As is inevitable in a series of papers read at a conference, the styles and presentations vary considerably, but one or two of the best papers are selected here for the electronics engineer interested in this subject. In the reviewer's opinion the paper on " Maintainability Design for the Airlines Avionics Market " is one of the most valuable contributions. It is worth quoting from an early paragraph:

" The average airliner will carry at least 28 different pieces of electronic equipment. Since there are more than 1,800 aircraft in daily service for the United States flying from 8 to 10 hours a day, the airlines are accumulating up to 500,000 equipment hours of service each day. Most of the equipment aboard these planes is bought on the competitive commercial market, but even so it is estimated that the airlines pay from $60,000 to $70,000 per airplane for this equipment.

" It has been stated that the US Air Force spends about $2·00 each year to maintain $1·00 worth of airborne electronic equipment. A quick check of the airlines shows that they spend only 15 to 20 cents of their total electronic investment dollar each year to maintain their equipment. The airlines normally pay considerably less for their electronic equipment and utilize it at a much higher rate than the military. The above

figure includes all maintenance costs including spare parts, but does not reflect an approximate 20 per cent investment in spare equipments. By looking into the reasons for the efficiency of the airline maintenance programme as well as the high quality of their maintenance, a number of interesting philosophies are in evidence."

This paper is one of the few papers to give practical data for the engineer, most of the remaining papers dealing with systems, organization, training, etc. The question of measurement of maintainability is discussed in one paper and referred to in the preface, but just as "Reliability" was (and still is, in many cases) difficult to measure, the problems of measuring maintainability are not solved.

The book as a whole is not easy to read and most users will select the papers in which they are directly interested. Although an attempt has been made to present the papers in some sort of logical sequence, the very width of the subjects covered makes this difficult. Unfortunately, there is no index to help the reader. Bibliographies are provided in some of the papers and none in others. A particularly detailed bibliography is provided by Rigney in his paper on "Improving Trouble Shooting by Training," but they are naturally all American in origin, which makes it slightly difficult for the UK user to obtain them readily.

In some of the papers there is a tendency to "pad out" data, which again does not help in the general reading of the book, but there is no doubt that the wide experience of the Americans in this field is useful to the British engineer and there are almost bound to be one or two papers in which he will be interested and from which he will gain valuable data.

The book is well produced, but the price (80*s*) is very high bearing in mind that only parts of the book will be useful to the purchaser, depending on the particular field in which he happens to be working.

In summary, the book records the valuable experience obtained in the USA, in servicing a wide variety of electronic equipments and although expensive, a little out of date and limited in value, is still worth consulting as a specialist book in this important field.

G. W. A. DUMMER

Apprentice to Craftsmen

Engineer Apprentice Manual. *Trade and Technical Press.* (42*s*)

In this manual, a first edition, have been collected articles which have already appeared in the now defunct monthly journal *Engineer Apprentice*, written for apprentices in the crafts of turner and machinist, fitter, patternmaker and moulder, sheet metalworker and toolmaker, and electrician. The authors, who remain anonymous, take the apprentice from his very beginning through to the responsibilities of the craftsman, with a section on entry to the drawing office. No opportunity is missed where stress should be laid on the importance of attaining the highest standard of workmanship, and on the patient acquiring of skill in the chosen craft.

The craft apprentice of today enters the engineering industry in one of two distinct fields: where the products come from mass-production, or in small batches or single units. Since 1945 provision of workshops in schools has been greatly increased, and most boys have had the opportunity to develop their talents from an early age to the point where they come into association with the skilled men from whom they gain the experience which will enable them to assume responsibility with confidence in themselves. Mass-production has by no means eliminated all opportunities for craft training, and in fact depends for its extension on the work of skilled men, but the selection of jobs for them during their apprenticeship itself calls for skill and has been a factor in the provision of apprentice training schools. When the output of a works is in units or small batches the opportunities for an apprentice to gain experience at all stages of manufacture should provide the ideal training ground for the skilled craftsman who is the cornerstone of the engineering industry. The wider this man's experience the better, and the merit of this manual lies in its collecting into one volume information on a variety of crafts.

The authors assume that the apprentice will attend craft courses at technical college throughout his apprenticeship and some reference to the City and Guilds certificates might well have been included. Except in the sections on sheet metalwork and press-tool making the writing is maintained at a level suitable for the first year apprentice, but in places, with a lack of clarity which is further marred by careless proof-reading.

Some subjects recur but no index is provided, nor a bibliography for those who may wish to take their reading to a further stage, and the young craftsman deserves better treatment than this in his reading.

T. A. O'NEILL

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Materials

Pre-Impregnated Fabric. LEICESTER, LOVELL AND CO. LTD., North Baddesley, Southampton. A folder, technical bulletin No. 479a, with inserted sheets, describing the characteristics and chemical and physical properties of Resnit. This is a knitted cotton fabric impregnated with a phenolic resin. The publication deals with the use of this material for the mass production of reinforced plastic mouldings of complex shape. 6 pp.

Countersunk Steel Bolt Specification. BRITISH STANDARDS INSTITUTION, 2 Park Street, London W1. Specification BS A211-1961 relating to 100° countersunk head steel bolts (unified threads and cruciform recesses) for aircraft. With the exception of the recesses, the dimensions and tolerances are the same as those given in BS 2A 173 for countersunk slotted head bolts. The basic principles and advantages of the flushness tolerance method for dimensioning countersunk heads are outlined, together with suggested methods of gauging. Details of the methods of gauging screw-driver recesses are given. 16 pp., illustrated. Price 12*s* 6*d* plus 6*d* postage to non-subscribers.

Wrought Steel Pipe. BRITISH STANDARDS INSTITUTION, 2 Park Street, London W1. Specification BS 1600-1961, giving dimensions of wrought steel pipe for the petroleum industry. An appendix lists the limited possible ASTM specifications, together with references to British plate steel specifications where appropriate. 6 pp., unillustrated. Price 6*s* plus 6*d* postage to non-subscribers.

Drawing Sheet Sizes. BRITISH STANDARDS INSTITUTION, 2 Park Street, London W1. BS 3429-1961. Sizes of drawing sheets used by the engineering, architectural, and building industries. 7 pp., illustrated. Price 3*s* plus 6*d* postage to non-subscribers.

Aluminium Roofing and Siding Sheets. ALCAN INDUSTRIES LTD., Bush House, Aldwych, London WC2. A loose-leaf catalogue, SfB File No. Nd4, comprehensively dealing with the costs, uses, application, handling and fixing of Noral aluminium roofing and siding sheets. Full particulars are included of materials available. Illustrated.

New Books

Scotland's Scientific Heritage. By A. G. CLEMENT and ROBERT H. S. ROBERTSON. *Oliver and Boyd.* (18*s*)

A history of the role of Scottish pioneers in the development of science, medicine and engineering from the Renaissance to the present day.

The Consulting Engineer. By C. MAXWELL STANLEY. *Wiley, New York and London.* (48*s*)

The professional and management problems involved in the practice of consulting engineering in the USA are dealt with. First, the consulting engineer's professional relationships to his client, to other consultants and to the public are investigated. Then a fairly detailed examination is made of the internal problems of a consulting practice. Sample contracts, description of grades of consultant and suggested classification accounts for consulting engineers are appended.

Proceedings of the 1961 Heat Transfer and Fluid Mechanics Institute. Edited by R. C. BINDER, M. EPSTEIN, R. L. MANNES and H. T. YANG. *Stanford University Press, Stanford, California; Oxford University Press, London.* (64*s*)

Seventeen papers were delivered to the meeting, held at the University of South California, 19-21 June. Among the fundamental research topics covered were axially-symmetric free mixing with swirl, heat transfer to steam-water flows, use of acoustic vibrations to improve heat transfer, heat transfer through a melting layer with external gas flow, and ionization trails.

Advances in Cryogenic Engineering. Volume 6. Edited by K. D. TIMMERHAUS. *Plenum Press, 227 West 17th Street, New York 11.* ($17·50)

Proceedings of the 1960 Cryogenic Engineering Conference, Boulder, Colorado. Nearly 70 papers were delivered, reflecting the advances that had been made up to the middle of 1960 in such areas as superconductivity, transfer phenomena, space technology, physical equilibria, thermometry, apparatus and mechanical properties.

Fundamentals of Electrical Measurements. By C. T. BALDWIN. *Harrap.* (25*s*)

Writing to satisfy the requirements of HNC and HND students, the author presents a concise introduction to the theory and practice of measuring instruments, meters and the techniques associated with measurement circuits. There are worked examples and chapter-end exercises (with answers). The m.k.s. system of units is used throughout.

Armatures and Field Coils. By KARL WILKINSON. *Spon.* (35*s*)

Based on a series of articles published in *Electrical Times*, this manual offers a detailed review of small armature and field assemblies, covering types of armature winding, insulation, the winding of armatures, the commutator and connections, armature testing, types of field winding, field-coil testing, and mechanical design. In the first place, this volume should appeal to the craftsman, but there is much of value to the designer and student.

The Reviewers

Dr. P. J. Grant, M.A., A.M.I.Mech.E., F.Inst.P., is University Reader in engineering science at Imperial College. He was formerly chief physicist of the atomic energy division of GEC, and has also been lecturer in natural philosophy at the University of Glasgow.

Mr. A. Sykes, O.B.E., B.Sc., Wh.Ex., M.I.Mech.E., M.I.Prod.E., is technical consultant to David Brown Industries Limited. He is also a Member of the S.A.E.

Dr. P. Chambadal is head of the thermal research department of Electricité de France. Author of 10 books and many articles, he is a member of the French Societies of Civil, Mechanical and Electrical Engineers.

Mr. G. W. A. Dummer, M.B.E., M.I.E.E., Sen.Mem. I.R.E., M.Brit.I.R.E., is head of components, constructional techniques and environmental testing divisions of the Royal Radar Establishment, Malvern. He has written several books on components and reliability and is a member of the Institute of Environmental Sciences, and of the Society of Environmental Engineers.

Mr. T. A. O'Neill, A.M.I.C.E., A.M.I.Mech.E., is inspecting engineer and training officer at Davy and United Engineering Company Limited. Previously he was responsible for apprentice training at Crewe railway works.

Marketing

Chocolate Manufacturer's Install Computer

The cocoa and chocolate manufacturers, CADBURY BROS. LIMITED, have placed a £300,000 order with FERRANTI LIMITED for an Orion high-speed electronic data processing system.

To be installed at the head office in Bournville, it will be used to handle 100,000 invoice items per day in addition to the preparation of sales statistics for management purposes. Eventually it will compile the payroll of the company's 12,000 employees.

At present the invoicing work is done by a punched card installation, using about 200,000 cards every day. The decision to transfer to a computer system was made as increased business demanded a new method of processing with greater capacity, higher speed and lower cost of operation.

Using permanently stored statistical data held in magnetic tape files and the incoming daily sales information, the computer will assemble the invoicing data in sequence for printing, and record it on magnetic tape. This tape will then be used to operate two output printers which together will have a capacity of 1,200 lines per minute. At this speed the complete job of calculating and printing invoices for one day is expected to take about five hours.

AEI Generating Plant at Eggborough

One of the main contracts involved in the construction of the Eggborough Power Station, near Knottingley, Yorkshire, has been awarded to ASSOCIATED ELECTRICAL INDUSTRIES LIMITED by the Central Electricity Generating Board.

The order, worth almost £14 million, covers the supply of four single-axis turbine-generators, each with a capacity of 500 MW at 3,000 rpm, condensing plants and turbine driven feed pumps.

The 500 MW design, developed from the 550 MW double-axis unit, concentrates the maximum capacity to date in a single-axis unit and is expected to result in the most economical generation in terms of capital and operational costs and thermal efficiency. Steam conditions are sub-critical: 1,050° F at inlet with reheating to 1,050° F, and 2,300 lb per sq. in. AEI also have under development a 375 MW turbine for supercritical steam conditions of 3,500 lb per sq. in and 1,100-1,050° F which will give higher efficiencies.

The first unit is due for commissioning in 1966 and the completed installation scheduled to be in operation by 1968.

More Town Centre Development

Another Midland town is to receive a face-lift with the redevelopment of the centre of Coalville, Leicestershire, at a cost of £1 million.

The contract for the work has been won by RICHARD COSTAIN (CONSTRUCTION) LIMITED and the scheme has been developed by Triland (Coalville), a subsidiary of Costain Property Investments. Demolition has already started and completion is scheduled for the end of 1963.

The project involves the construction of a large pedestrian precinct with an adjacent car park for 350 vehicles. There will be 67 shops including a supermarket occupying a floor space of 16,500 sq. ft. A town square in the centre will be free of traffic and its sculptured centre-piece is to be the subject of an open competition.

Architect for the scheme is H. Owen Luder and the structural consultants are E. J. Cook and Company (Engineers) Limited.

Electric Motors for Rumania

CROMPTON PARKINSON LIMITED have received an order worth £100,000 to supply electric motors to a large paper mill at Calarasi, near Bucharest in Rumania.

The contract was obtained through LYDDON AND COMPANY and over 400 motors are involved, ranging in size from ½ hp to 1,000 hp; totally-enclosed or splash-proof.

The mill, using straw as a raw material, will be one of the largest of its kind in the world and the Crompton motors will be used for the preparation plant and other duties.

Large Dragline for Italy

A large walking dragline is to be used for stripping overburden from lignite coal deposits in the province of Potenza in Italy. The machine, a Rapier W1800, will cost nearly £1 million and has been ordered by the Società Meridionale di Elettricità. The overburden consists mainly of marl and shale: the lignite will be used as fuel in a thermal power station which will be built in the vicinity.

The dragline will be fitted with a boom 265 ft long of lattice and girder work construction in high tensile steel. The 40 cu. yd bucket will be of the "Esco" triple tapered type, and will operate at a radius of 245 ft. The total weight of the machine will be about 1,800 tons which will make shipping difficult.

The Rapier W1800 has been developed from the original W1400 first manufactured in 1951. A W1800 is now operating in South Wales for the National Coal Board, and another machine is being constructed for Stewarts and Lloyds Minerals Limited for working in the ironstone mines near Corby.

Tenders Submitted for Indus Barrage

The formal opening, on 12 December, of international tenders submitted for the construction of the Sidhnai Barrage marks the approaching commencement of work on five barrages to be built at an estimated cost of £9 million as part of the vast Indus Basin Project. The object of this first stage, commissioned by the Water and Power Development Authority of West Pakistan, will be to transfer water from one link canal to another across the bed of the Ravi.

When completed in about 10 years time, the entire project will have cost in the region of £360 million and will provide water to some 5 million acres. It was conceived as a solution to the dispute between Pakistan and India over the division of the waters of the Rivers Sutlej and Ravi. Two large storage dams will be built in the Himalayan foothills and the five barrages, together with system of link canals, will transmit water across the Indus and its tributaries in the Pubjab plains and from three western rivers to the areas in the east formerly irrigated by the Sutlej and Ravi.

The project, which is backed by the World Bank, is financed by grants from Britain, the USA, Canada, Germany, Australia, New Zealand and Pakistan, by a fixed sum towards the cost of replacement work from India, and by a World Bank loan.

In addition to the Ravi barrage, the work covered by the present tenders includes a regulation for the link canal, a new railway bridge about 800 ft long, a new road bridge 1,000 ft long and various ancillary works.

Of the eleven firms expected to submit tenders at the public opening, only the second occasion this practice had been adopted in this country, the contract price in rupees of tenders of five of these firms were announced.

These were: Société Dumez, France—Rs 122,503,202; Costruzioni Generali Farsura SPA, Italy—Rs 129,500,000; Ed. Zublin AG, West Germany—Rs 144,134,174; Compagnie Française d'Enterprises, France and Pakistan—Rs 153,776,955; Morrison-Knudsen (Pakistan) Co. Inc., USA—Rs 178,723,400; (*NB.*—One £=13·333 Pakistani rupees).

Assessment of the tenders is expected to take some weeks as there are many points to consider and the possibility of escalation clauses and other circumstances may prejudice financially favourable tenderers.

The consulting engineers who have collaborated with the Development Authority in the design and specifications of the works are as follows:—

Development plan: The Harza Engineering Company, USA.
Dams and Power: Preece Cardew & Rider, London, and TAMS, USA.
Barrages and Regulators: Coode and Partners, London.
Link Canals: Tipton and Kalmbach, USA.

The advisers to the World Bank are Sir Alexander Gibbs and Partners, London.

Massey-Ferguson Sales Increased

The estimated sales of MASSEY-FERGUSON for the fiscal year ended 31 October, 1961, were $519 million, an increase of $29 million or nearly 6 per cent over the previous year. Announcing the figures, the president, Mr. A. A. Thornbrough, said that this was the first time in the company's history in which sales had exceeded $500 million level and emphasized the record sales established in the UK and Germany.

New Water Supply in Kuwait

The natural resources of the Arabian Shiekdom of Kuwait include an abundance of oil but little fresh water. At present about 90 per cent of the latter is obtained from a distillation plant, and the recent discovery of a new source of supply at Rawdatain, 55 miles north west of the township of Kuwait, has been most welcome.

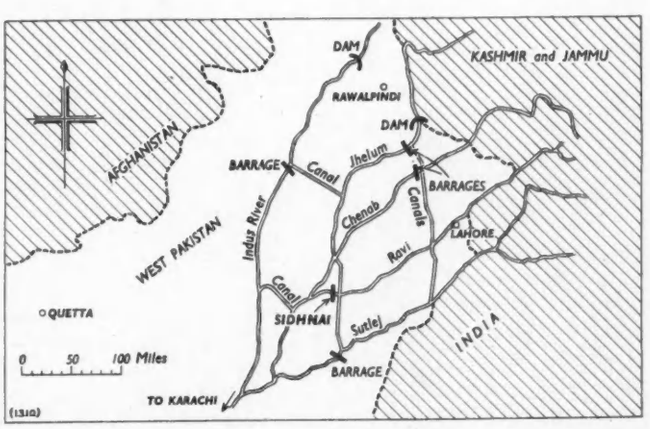
Its potential has been estimated at 5 million gallons per day for the next 20 years and the Government department of water, gas and electricity have awarded RUSTON AND HORNSBY LIMITED of Lincoln a contract, worth nearly £250,000, to supply equipment to drive the pumping gear.

This will comprise six gas-turbines, three of the TE class rated at 430 bhp, and three of the 1,260 bhp TA class units. The smaller turbines will drive alternators to provide power for the motor driven Peerless pumps which will lift the water to the surface where three centrifugal pumps, coupled directly to the TA turbines, will pump it to Kuwait town.

Two types of fuel may be used, the primary being natural gas obtained locally from the Kuwait Oil Company. In the event of a break in the gas supply, it is a simple matter to change over to diesel fuel.

To combat possible power fluctuation on the TE turbines, due to the high ambient temperature and low humidity, the air supply will pass through humidifiers which will have the effect of reducing the temperature at the turbine inlets.

Delivery of the turbines is to take place in two batches during May and July, 1962, and the plant is expected to be operative by the end of the year.



Plan showing the locations of the many stages in the Indus Basin Project, designed to bring irrigation water to 5 million acres. The complex systems of dams, barrages and canals will take over 10 years to complete and cost at least £360 million.

Monotype Composition Caster

Any machine used by the printer, working against a deadline, must be proof against the possibility of sudden breakdown. In this machine full advantage has been taken of over 60 years of operational experience.

YOU ARE reading Times New Roman 9 point type composed on a Monotype Composition Caster—one of the outstanding mechanical devices of this century.

In the course of the continual quest for products sufficiently successful and well established to qualify for Product Profile, a machine has been chosen for this week that is used in the production of ENGINEERING. It is in fact employed for many books, magazines and catalogues, and in practically every country of the world.

" Monotype " is the registered trade mark of the Monotype Corporation Limited who produce the caster. It is a machine which works from a paper ribbon in which perforations have been pneumatically punched on a keyboard in another room, to correspond with characters on the manuscript.

The machine casts independent characters, punctuation marks and spaces at the rate of up to 3 per second. As each line is completed it is delivered into a " galley " with each word correctly spaced to suit a predetermined length of line, ready to be made up in page form and taken to the printing presses.

For some uncanny reason, the Monotype caster engenders a spirit of enthusiasm mixed with wonder in nearly everyone it meets. Talk to Harrison and Sons Limited, printers of ENGINEERING, or to any of the Monotype Corporation's staff. They will agree that the caster seems to possess some fatal charm.

The caster, in eliminating the time-consuming drudgery of hand composition, is necessarily intricate. The essence of its success is the finesse with which it performs. Imitation has many times been attempted—but for some subtle reason, no matter how blatantly the design is copied, the result is always inferior. The Monotype Corporation's business has been built up on producing a machine, together with its ancillaries, which stands alone; a vital necessity to the civilized world.

Fig. 1 The composition caster.

The caster is the focal point of a service which the Monotype Corporation have been offering the printer for over 60 years. Apart from making possible a great improvement in the appearance of the finished print, the choice of different " type faces " has progressively increased. Today the company offer a choice of over 600, in sizes ranging from 4½ to as large as 72 point, and there is a waiting list of requests for new type faces. The caster is capable of working from the smallest size up to 14 point—or up to 24 point with attachments.

Each letter or character is cast in a tiny bronze mould manufactured by the Corporation and known as a " matrix." The matrices are mounted in a matrix case as shown in Fig. 3, small enough to be held in the palm of the hand. For type up to 14 point there is room for 255 matrices, arranged in 17 rows with 15 in a row. So a typical piece of printed matter may contain a choice of up to 255 different characters made up, for example, of capital and lower case letters, roman, bold and italic; figures, mathematical symbols and punctuation marks, with spaces to spare. With the composition caster, up to seven alphabets are obtainable in one setting.

FIRST PATENTS

The first patents for the Monotype composition caster were taken out in 1887 by an American, Tolbert Lanston; but like so many famous machines, it did not get off to a very good start. True, the world had been waiting for 450 years for a device to relieve the tedium of hand composition—but another American, Mergenthaler had just invented a machine which composed complete lines instead of single characters. Initially in both machines the type was cold punched and not cast hot.

Today line composing machines are made under two names, Linotype and Intertype. They, too, have a place in the market for printing machinery, particularly in newspaper work. The factors governing the printer's choice as to whether to invest in a single type or line composing machine are too complex to be entered into here; but the chief advantages of single type composition are, namely:

(1) the ability to offer superior quality type straight off the machine, with the consequent saving of overheads in the time taken to make the forme ready for the printing press.

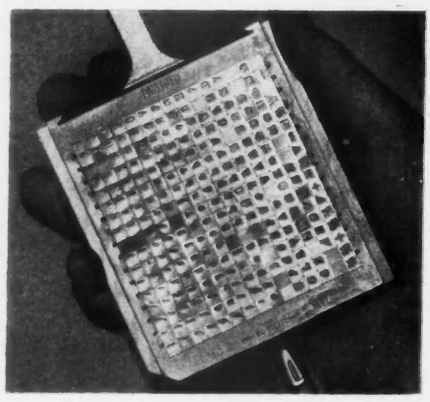
(2) the ease with which simple corrections such as two accidentally transposed characters may be made.

The quality aspect has undoubtedly done much to establish the present day reputation of the machine. This advantage was not appreciated at the time of Lanston's invention, so in 1897 four machines were brought to England where hand composing was still the rule. The company's representatives were fortunate enough to meet the Earl of Dunraven during the Atlantic crossing, and he became so enthusiastic that he later gave the project invaluable financial help.

The first step was to form a syndicate to purchase the British manufacturing rights, from which the present company has grown independent of the company across the Atlantic. In the first few years many difficulties had to be overcome, including delays due to technical improvements being made in America; teething troubles causing sudden breakdowns; printers' reluctance to purchase expensive and relatively untried machines; and recruitment and training of operators and service technicians. That they were finally solved proved beyond question the potentiality of the machine.

Fig. 2 The keyboard operator at work.

Fig. 3 (below) The matrices in their case.



The company's first premises were in London, but as early as 1899 a large factory site was purchased in the heart of the country at Salfords, on the main railway line between London and Brighton. Initially complete machines were shipped from America, but the factory soon began assembling them from imported parts and about 1923 commenced full production.

A few radical alterations occurred in the caster's early formative years, after which the machine settled down to a period of steady if not fundamental improvement. At first glance the current model, shown in Fig. 1, might easily be mistaken for one of 1901. In fact, though the working principles remain unchanged, there is hardly a part of the machine that has not been redesigned at one time or another in the light of hard, practical experience.

Within the brief confines of this article it is impossible to describe in detail the working of the composition caster. Undoubtedly its heart is the mould in which the casting takes place, shown in Fig. 7. Into the central aperture molten type metal (a lead-antimony-tin alloy) is pumped successively to form each character. Just prior to each instant of pumping, the matrix case is lowered to the mould's upper surface, with a previously selected matrix positioned directly over the aperture. A coned pin engaging in the rear of the matrix then accurately positions

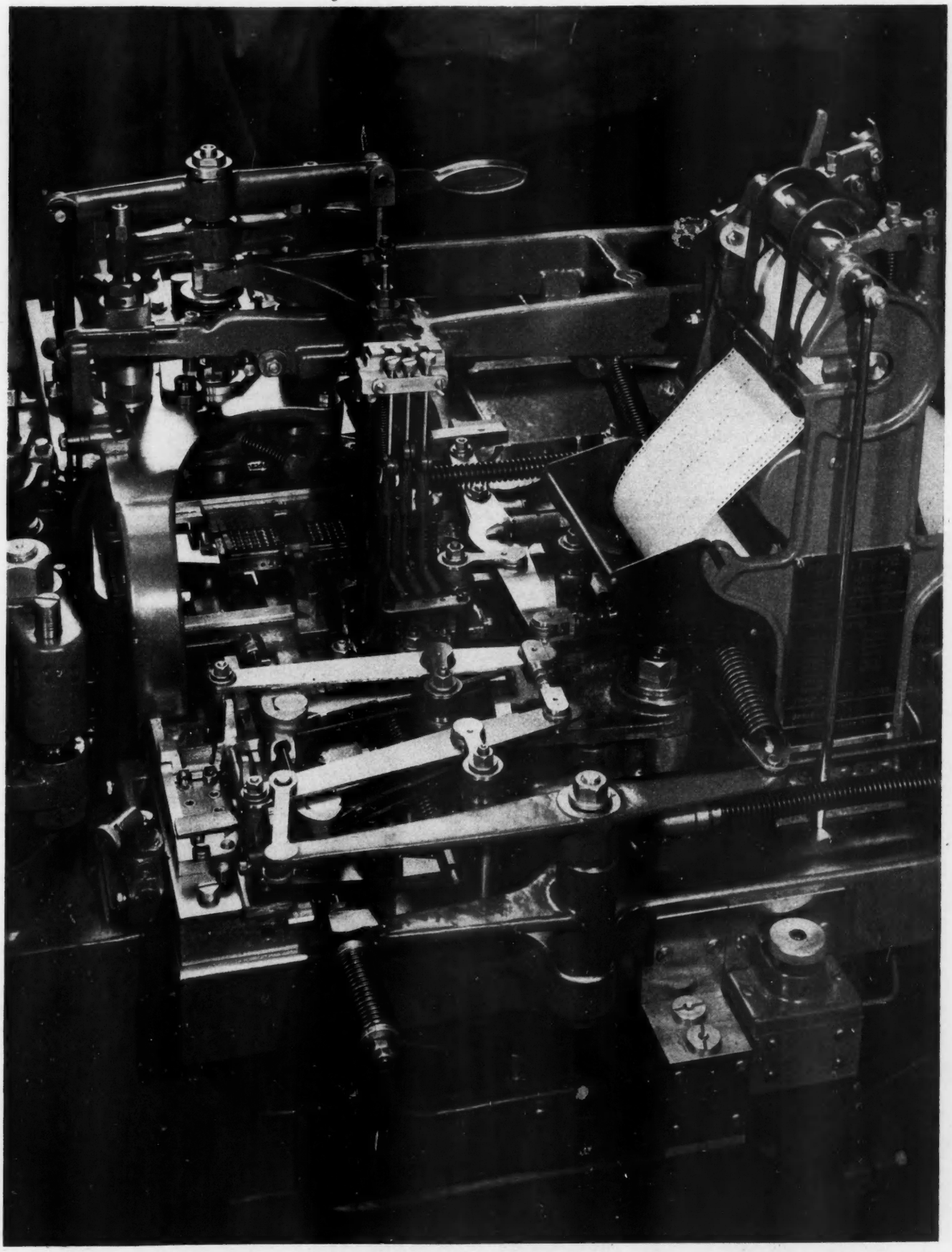


Fig. 4 Mechanical ingenuity and operational finesse give the user a machine on which his livelihood depends.

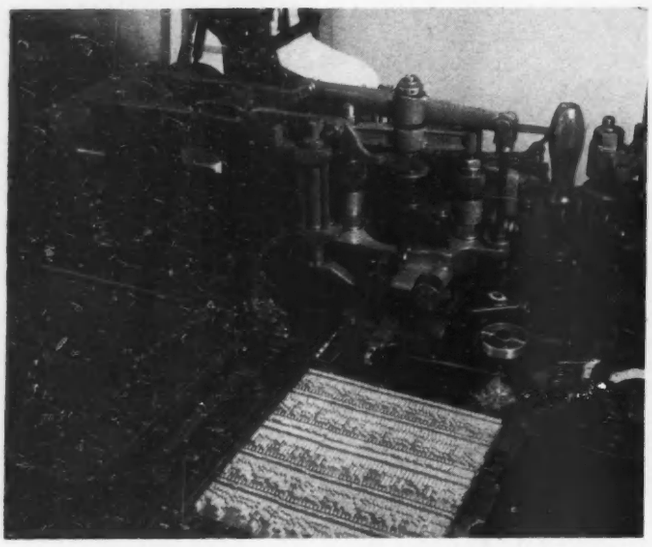


Fig. 5 The completed type emerging from the caster.

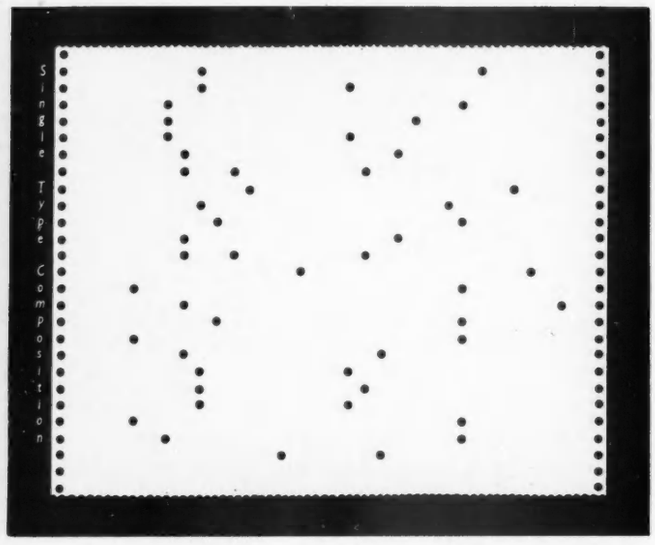


Fig. 8 The paper ribbon from which the caster receives its instructions.

and retains it, as shown in Fig. 6.

When pumping occurs, both the aperture and the matrix become completely filled with type metal; it solidifies almost immediately and is ejected, while the matrix case is raised and repositioned ready for the next casting. The aperture itself is adjusted to one of 15 standard widths to suit the character concerned, by a sliding blade whose travel is controlled by a bar wedge known as "a normal wedge." The blade is made in two sections so that spaces between words can be cast suitably less in height than character types. The width of the spaces is controlled by "justification wedges."

The vital characteristic of the mould is to cast the molten metal, which is under pressure, clean and square with no trace of burrs. Superb fit, therefore, has to be maintained between its moving parts and between its upper surface and the matrix. Cooling water circulation is provided to prevent the mould overheating.

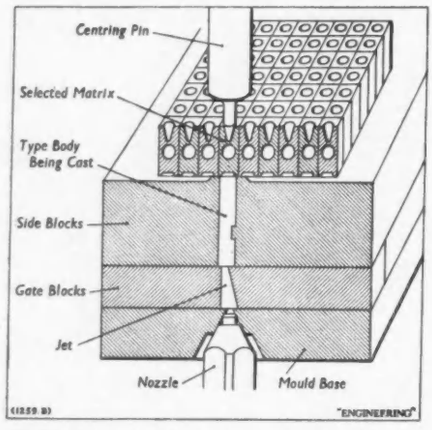
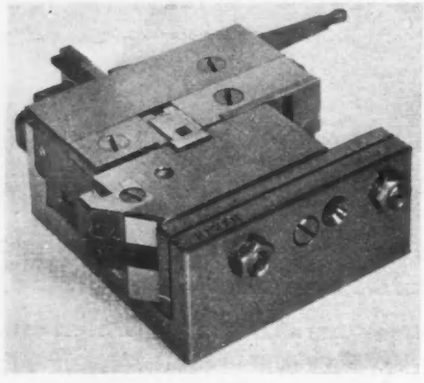


Fig. 6 (above) Diagram of casting operation.

Fig. 7 (below) The mould itself.



The mould's useful life used to be determined by the rate of wear of its upper surface around the aperture, but the present system is to provide a non-wearing matrix seating surface. Perfect uniformity in type height is absolutely vital to the printer, which emphasizes a particular virtue of mechanical as opposed to hand composition in that the type is thrown away after use and re-melted, obviating any undesirable mixture of worn and unworn type.

Each of the casting operations, which take place at the rate of up to three per second, must be preceded by distinct signals fed to the machine. For casting a character two signals are used for positioning the matrix case along its two axes to select the matrix; and for positioning the normal wedge to control the aperture width. Where justifying spaces occur, a space signal must be added to the matrix positional signals to call into play the appropriate previously positioned justification wedges in order to space the line.

These signals are provided by the perforations in the paper ribbon $4\frac{5}{16}$ in wide, which has a total of 31 possible positions. Depression of any button on the keyboard usually produces two perforations, the combination of which selects the required operation, in a similar manner to a pianola or a keyless mechanical organ.

On the caster the ribbon travels over a tracker bar with 31 corresponding perforations, mounted near the top of the "air tower," prominent in Fig. 4. Low pressure compressed air is directed through the perforations to the underside of pistons in two blocks, one at the rear of the machine and one at the front. The pistons rise as required to initiate the appropriate movements on the machine, which are performed by a system of cams and levers.

For sheer ingenuity, the justification system for giving the correct equal spacing between the words in each line is second only to the moulding sequence; but it is too involved for more than a brief mention in this article. The keyboard, which resembles a giant typewriter, carries a vertical graduated drum and a horizontal scale which indicates the room left in the line. When the line is full of words, the keyboard operator presses two special buttons according to the indication of a rising pointer on the drum, which meanwhile has rotated.

The paper ribbon is then punched with the justification signals required by the caster. The machine must receive them *before* it commences casing the line, so that the justification wedges can be correctly positioned, so for this reason it works from the ribbon in the opposite direction to that of the keyboard operator. In other words, the last operation to be made on the keyboard is to provide the first signal which affects the operation of the caster.

The molten type metal is stored in a pot heated by electricity or gas, from which it is forced as required by the pump. The pot is replenished by means of a cold ingot which is gradually fed in under the control of a float.

Many of the optional attachments would require a too involved description to mention. They include a display type attachment for producing founts from 14 to 36 point (necessitating a speed reduction to allow the type to solidify properly); lead and rule casting attachments; and a large type attachment for children's books.

In a world where the prevalence of the printed word still varies considerably from country to country, there is a tremendous overseas market for printing machinery. The Corporation export over two-thirds of their composing machines and the demand is continually growing. The company employ 2,000, and the works have gradually expanded until today they have almost reached the limit of the plot of land so wisely purchased at Salfords in 1899.

Each manufacturing operation on the caster is fully jigged and tooled, and over a 100 inspectors strive not only to maintain, but, if anything, improve the precision standards of accuracy for which the machine is renowned. Not content with this, each machine has to pass through a 100-hour running-in period, followed by further stripping and inspection before despatch.

Production of the caster is by no means the whole story. Design, manufacture and storage of matrices are of equal importance. For the first 20 years or so of the machine's existence, its ability to use a wide choice of type faces was not recognized; but times have changed.

What does the future offer? After a lengthy research, development and prototype testing period, the filmsetting process has reached the stage that mechanical single type casting had attained 50 years ago. The company now have "Monophoto" filmsetters in production. *The Monotype Corporation Limited, Salfords, Surrey.*

Predicting Conclusions from Protracted Life Tests

By J. L. Cribb, B.E. (Mech.)

In many types of life testing, including fatigue, a number of test pieces from a sample are tested concurrently. This means that, during the test, some test pieces will have failed, some will still be under test and some will not yet have commenced testing.

The engineer who wants an estimate of the mean life has generally to wait until some numbers of test pieces have failed since, if he calculates a mean early in the test, the answer will be biased towards the low end. Further, while there are still some test pieces being tested, the information that their lives are greater than the time for which they have so far been tested will be wasted unless it is somehow taken into account.

In the case where either naturally or after some simple transformation the variation in life is described by the Normal Distribution Law the following method of analysis may be found useful.

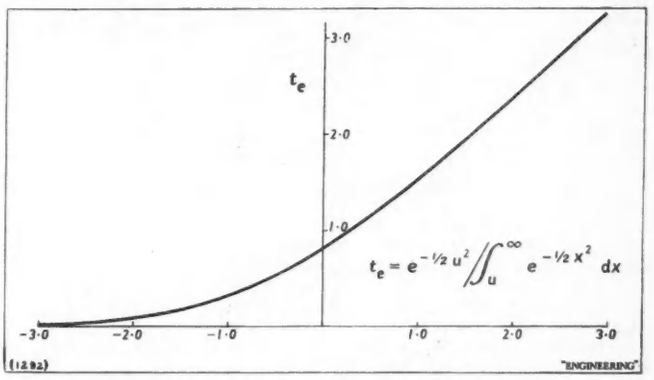
Suppose that the lifetime values, based on this normal distribution, of failed test pieces are denoted by x and that of surviving test pieces by y. Suppose there are j values of x and k values of y. Then estimates of the mean (m) and standard deviation (s) are obtained by

(i) standardizing x and y according to the equations

$$t = \frac{x - m}{s}$$

$$u = \frac{y - m}{s}$$

where m and s are not accurately known at this stage;



Graph for transformation of values of u to values of t_e. Use of this curve forms the second of three stages in the process of prediction.

(ii) transforming u to t_e by means of the curve illustrated, and

(iii) solving the equations

$$\sum_{1}^{j} t + \sum_{1}^{k} t_e = 0$$

$$\sum_{1}^{j} t^2 + \sum_{1}^{k} u\,t_e = j - 1$$

for m and s.

In practice one starts with the best estimates of m and s available and solves the equations by guided trial and error, stopping when the answers are sufficiently accurate. The time taken to solve the equations is usually negligible compared with the time necessary, in testing more test pieces to failure, to achieve the same amount of statistical information. At least two test pieces must have failed before the method will give an estimate of both m and s.

This procedure for estimating m and s has been derived by application of the Method of Maximum Likelihood.

A procedure for use in the special case when all values of y are equal is described by A. Hald, *Statistical Theory with Engineering Applications*, published by Wiley and Sons Incorporated, 1951.

This note is published by permission of the Chief Scientist, Department of Supply, Australian Defence Scientific Service, Melbourne, Victoria, Australia.

Analogue Instrument for Optimizing Processes

Industrial processes involving variables such as pressure, flow and temperature, can now be optimized by a simple analogue computer which has been developed by Honeywell Controls Limited, Greenford, Middlesex.

Primary variables can be controlled in such a way that an uncontrolled secondary variable can be kept at an optimum level, appropriate to prevailing conditions. As conditions change, a new optimum level will be sought and maintained.

The secondary variable is related to the primary variable in such a way that there is one point of maximum or minimum. Rather than the variables being related by a fixed curve, as in the conventional closed loop, they will be related by a family of curves each having a single point of maximum or minimum value.

This equipment makes use of a new electric measurement and control system introduced earlier this year by Honeywell; it permits a set point to be changed simply by feeding in a fresh signal.

The principle of working can be best explained by assuming that the secondary variable is to be at a maximum. A short-term disturbance is introduced into the primary channel, causing a corresponding change in the secondary variable which can be detected by a suitable transducer. This latter change is compared with the previous steady state value of the secondary variable and the difference is detected by a decision amplifier.

If the change is positive, a further disturbance, in the same sense as the first, is introduced into the primary channel and its effect checked as before. This process is then repeated to the second steady state value. When this occurs, the sense of the disturbance is reversed and its effect checked. Once the point of maximum is reached, alternate positive and negative disturbances are introduced at regular intervals and, in either case, the resultant change in the secondary variable should be negative.

Because of the time lag inherent in most processes, a memory unit is incorporated to memorize the direction of the previous disturbance applied to the primary variable so that this may be correlated with the change in the secondary variable. An analogue memory is also provided to retain the steady state value of the secondary variable so that this may be used for comparison purposes.

The duration and amplitude of the short term disturbances are determined by the conditions of the process, as also is the interval at which the pulses are introduced.

Transducers for Ultrasonic Control

Simple and efficient remote control without electrical cable or electronic link will be facilitated by the introduction to Britain of two transducers which were recently developed in the United States. These transducers are suitable for both transmission and reception and cover bandwidths up to 13 kc/s.

In the commercial field, low power ultrasonics are currently being used for a variety of purposes in America. These include remote control of television receivers and other household equipment, opening and closing of garage doors, main door admission to blocks of flats, remotely controlled models, and alarm systems.

In the industrial field, the two new transducers could have many applications, and would be particularly suitable for use in connection with the control of intermittent and variable production processes, remote control of factory gates and doors, movement control of mechanical handling vehicles, and a number of laboratory functions.

Apart from its simplicity and sensitivity, one of the main advantages of ultrasonics for control is that it does not affect similar systems nearby. An additional asset is that it can control electronic equipment without interfering with the latter's working characteristics. Ultrasonic equipment is interchangeable with operating devices in other systems and existing arrangements for mechanical and electrical response remain comparatively unaffected by its introduction.

The two new transducers measure about 1 in in diameter by 1¼ in in length. The basic model (type 1404) has a wide directional beam of 65° with a loss of 6 decibels at the outer edges of the beam. The bandwidth is 4 kc/s, but narrower bandwidths can be arranged by using a shunt or series capacitor.

Basically, the ultrasonic links which could make use of these devices are of four types: a continuous-wave transmission (single channel) for the operation of doors or any similar single-function operation; a pulse transmission system (single-channel) for control of intermittent production processes, etc.; a pulse transmission system (multi-channel) for controlling several functions in domestic or industrial equipment; and an amplitude-modulated multi-channel system (without pulse) for fine selectivity.

Gulton Industries (Britain) Limited, of 10 St. George's Place, Brighton, will be marketing the two transducers. The type numbers of the devices are; 1404 and 20Q01.

The microphone is used with an inductor to achieve the 4 kc/s bandwidth necessary for 4-channel television control and it is used without an inductor for continuous wave or amplitude modulated systems of single carrier frequency operation.

Research: Efficiency before Expansion

Universal agreement seems to have been reached on the importance of research and the need for greater effort. But, at the same time, attention should be paid to increasing the value of our existing resources.

INTELLIGENT observers of industrial history and development have always urged the importance of research. At one time, their words of wisdom may have gone unheeded—but not now. For the past decade or so, the "message" has been repeated again and again, with ever increasing vigour, until there can be no doubt that there is now widespread appreciation of the importance of research (and development) coupled with an urge to participate in the emerging era of science-based industrial effort.

Based largely on the newly published FBI/NIESR survey of industrial research, which clearly shows industry's general desire for increased effort, this Research Report discusses four of the major factors governing the efficiency and effectiveness of our *current* resources.

Manpower

Undoubtedly, the first bottleneck encountered by the comparatively sudden expansion of research activity in recent years has been a shortage of qualified scientists and engineers.* Much has been said about this and it is generally agreed that the remedy rests with the education authorities, both in industry and government, whose responsibility in this respect is to ensure that there are adequate training facilities available to meet the long-term needs of industry. Expansion programmes at universities and technical colleges are already in fairly full swing and it is estimated that 47,000 new QSE's (Qualified Scientists and Engineers) will be available during the three-year period ending in 1962—but this will not be enough. The FBI survey clearly shows that the manpower requirements created by current research expansion will not be met by the present-day expansion rate of QSE output.

In fact, the true situation is possibly even worse than the FBI statistics indicate. Their survey showed an overall vacancy rate of 14 per cent for QSE in industrial research and development. However, this figure was based on response to questions which were posed in the light of a chronic, and well-known shortage. In other words, firms were not asked how many more QSE they could usefully absorb if their present research programmes were not already geared down to the present-day shortage of manpower. If they had been asked this rather hypothetical question, it is almost certain that the (idealized) requirements of industry would have shown themselves to be substantially greater than a further 14 per cent.

This point was confirmed to some extent in another section of the survey which indicated that quite a number of industries would like to increase their research and development facilities by 25 to 50 per cent, if there were no (financial or manpower) restrictions.

It is a fact, therefore, that there is a current shortage of QSE in engineering industries, and it seems highly likely that this shortage will be with us for some time. What then, if anything, can be done to alleviate the situation in the near future?

Professor Bruce Williams, on behalf of the National Institute of Social and Economic Research, comments on this question in a preface to the FBI survey. In the first place, he points out that the balance of our effort, both in terms of manpower and finance, shows signs of being "out of true" in that too much emphasis is placed on basic research. He cites three issues which point to this conclusion: (1) development by foreign industries of an unduly large number of basic discoveries made in Britain; (2) many cases of unused industrial research which appears ripe for development; and (3) an excessively large output from research and development departments which is not used because it is not worth using.

As Professor Williams points out in his commentary, it is very difficult to assess evidence of this kind. However, the survey itself produces some statistical justification to his comments through its analysis of research expenditure. In this analysis, the proportion of research and development funds devoted to basic research emerges at the surprisingly high figure of 6·5 per cent (excluding the aircraft industry, this figure becomes 9 per cent). This means that private manufacturing industries are spending more than half as much on basic research as the universities. More significant still, British manufacturing industries appear to be spending almost twice as much on basic research as their American counterparts.

Allowing for the fact that the term "basic research" is capable of a number of interpretations, it would still appear that some profit might be gained by a readjustment of the balance of effort between basic research and technological development.

Another factor that may possibly affect the *optimum* use of QSE on industrial research and development is the large amount of Government contract work. The FBI survey shows that, apart from the aircraft industry, nearly 1 in 10 of all, and 1 in 4 of the large, respondent firms have direct Government research contracts. Of the men employed in this work 75 per cent are in electrical engineering with a further 10 per cent each in non-electrical engineering and in chemicals. This, naturally, leads to fears that future changes in Government policy could dislocate research and development organizations, particularly in the electrical and aircraft industries (the latter employs two-thirds of its QSE on Government work).

There appear to be two opposing views about Government contracts in industry. Some firms see it as unwelcome competition for research and development resources at a time of acute shortage of manpower, and cite examples whereby reduced government expenditure has enabled them to take up useful civil projects that might otherwise have been stifled. Other firms report that Government-initiated projects have been of direct benefit in the civil field.

"External" Research Organizations

It is perhaps surprising to learn that only a small proportion of research and development expenditure in industry as a whole is devoted to work other than that carried out within the firm—if the aircraft industry is excluded, only 4 per cent is spent on external research. Of this, about two-thirds goes to the research associations aided by the Department of Scientific and Industrial Research (there are currently fifty-one of these), and the remainder goes on direct payment for work done by universities, DSIR laboratories, sponsored institutes, the National Research Development Corporation, consultants, etc.

One would expect to find research associations well backed by small firms, since the cost of membership (which is made proportional to the size of the firm) is infinitesimal compared with the cost of running a viable research and development department within a firm. However, the survey shows that only one-third of the small firms belong to research associations whereas nine-tenths of the large firms are members of at least one, and half of these are members of four, or more.

It is generally thought that the problem of communication between research associations and the industries they serve is in one direction only—from researcher to user. However, by the unequal level of contribution made by the various research associations, the survey indicates that there is a problem of communication in the opposite direction. If this is so, then it means that some of the industrial committees, which exist to guide the activities of research associations, are not fully conversant with the research needs of their own industries.

On the subject of external research facilities, another revelation made by the survey is that, although there is a general demand for improvements in external research facilities for engineering†, there is no demand for an increase in the number of research associations or sponsored research institutes.

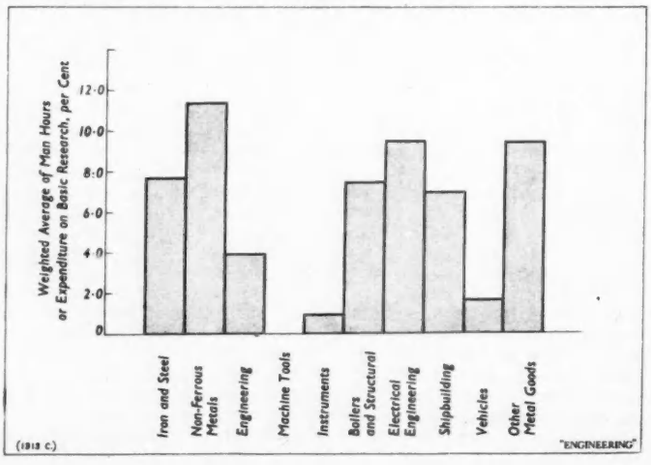
* In this report, qualified scientists and engineers are as defined by the Advisory Council on Scientific Manpower. This does not include holders of the Higher National Certificate/Diploma.

† Where the term "engineering" is otherwise unqualified, it refers to a grouping of the following industries: agricultural machinery (excluding tractors), industrial engines, textile machinery and accessories, contractors' plant and quarrying machinery, mechanical handling equipment, office machinery, other machinery (food, paper, mining, printing, pumps, compressors, etc.), ordnance and small arms, ancillary mechanical engineering (bearings, chains, repairs, etc.).

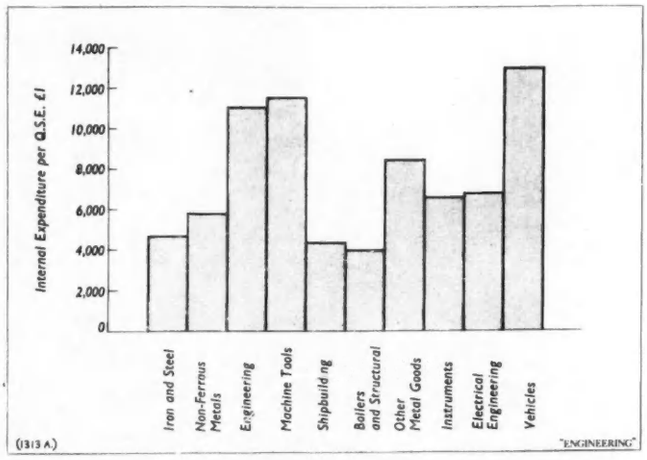
Research Report

based on

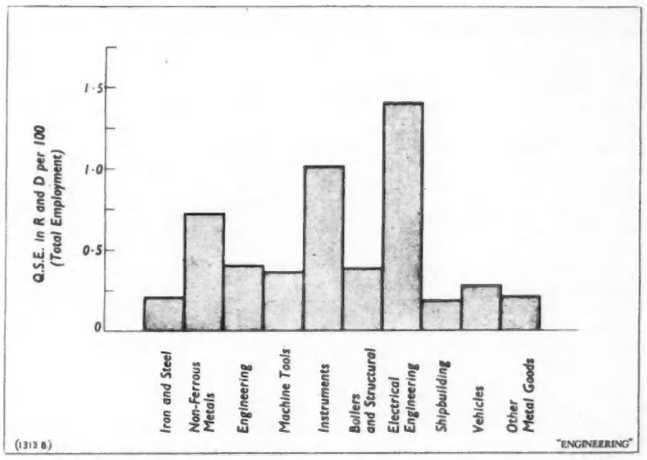
"Industrial Research in the Manufacturing Industry, 1959-60", a survey published by the Federation of British Industries and carried out jointly by the FBI and the National Institute of Economic and Social Research.



A surprisingly high percentage of research and development effort in British industries is placed on basic research.



Expenditure per qualified-scientist-and-engineer varies considerably between different industries.



The number of qualified scientists and engineers per 100 employees is taken as the main criterion of research done.

The survey, which embraced all types of manufacturing industries, showed that engineering, boiler and structural and other metal goods firms spent proportionally less on external research than others. Furthermore, small and medium firms in engineering spend proportionally less on external research than large firms, which is not the case in other industries. This could mean that small and medium firms in engineering are not aware of the value of research associations and other external laboratories, or that the large firms spend more than is necessary. But a third possibility, that the established external research facilities do not cater satisfactorily for smaller firms, must not be ignored. In fact, some respondents touched on this point when they criticized external research organizations for being remote from the practical problems facing firms. The comment that they are "insufficiently aware of cost and production problems" was quoted in the survey.

However, although there were several criticisms of research associations and other external bodies, a number of favourable comments were also received. For example, the shipbuilding industry said that research associations were "helpful especially in the cases where scientific officers and the industrial staffs have worked together throughout the study." Professor Williams' commentary on the survey emphasizes this point by saying that "more interchange of personnel, seconding of staff, joint work on specific projects and other forms of practical cooperation would be beneficial."

When probing for industry's comments on the value of existing external research organizations, one of the questions asked by the FBI was whether "there exists a substantial number of promising projects which are too long-term or too expensive for a single firm, which ought to be undertaken by your industry as a whole." The majority of answers to this question seem to have been singularly disappointing. Some firms answered just "yes" or "no", without qualification; others said that there were gaps, but gave few good examples; the remainder quoted projects which were found to be already the subjects of research activity in one or more of various well-known Government or industrial laboratories.

Management

The variations and ambiguities in these replies make any kind of analysis quite impossible. For instance, those who suggested research projects which were already under way elsewhere might have meant that greater emphasis should be placed on these projects, or they might merely have been ignorant of the current programmes of the other laboratories.

However, one thing does seem certain—many of the survey's respondents were quite unable to express clear-cut views on the overall research needs of their own industry. As Prof. Williams puts it: ". . . a reading of the answers to this question suggests the need for a more co-operative approach to the problem of priorities."

Another, more speculative, interpretation that could be made of these replies is that some research managements have an insufficiently broad outlook. If this is true, then many dangers arise—overlapping of effort between firms; wasted expense on work which has already proved fruitless elsewhere; an inability to see the potential gains of new developments in other fields, etc., etc.

There is in fact another serious danger that arises from an unenlightened approach to research management—particularly in the day-to-day running of the laboratory—and that is a failure to achieve the maximum response from the research staff.

Men who take up research as a career are almost a breed apart. Without making too sweeping a generalization, it would be true to say that the majority of them have certain characteristics in common (one of these being a well developed analytical faculty) which make them very sensitive to the standards of their management.

Examples of this subtle factor in research efficiency can be readily seen without attempting the impossible task of making quantitative comparisons. One has only to spend a short while in some laboratories to sense a general atmosphere of indolence and apathy. When this is accompanied by an exceptionally high staff turnover, particularly if the brightest ones tend to leave more readily, it may well be taken as a sign of poor or mediocre management.

Looking at it from the other side, there are some laboratories where the general air of enthusiasm cannot possibly be accounted for without giving at least some degree of credit to the managers. It may well be that the human element is more critical in research than in other fields. Closer attention to the matter would certainly be rewarding.

TABLE I.—*Qualified Scientists and Engineers and Internal Expenditure on Research and Development.*

Industry	QSE in R and D		Internal expenditure on R and D.		
	Number	Per cent of total	£ million	Per cent of total	Per QSE £
Chemicals ..	6,597	23	34·3	14	5,207
Electrical engineering	8,037	28	55·2	22	6,872
Aircraft ..	4,290	15	89·3	36	20,816
All other ..	9,667	34	71·4	28	7,386
Total ..	28,591	100	250·2	100	8,751

TABLE II.—*Research Ratios by Size Groups Based on QSE on R and D per 100 Total Employed.*

Industry	Large	Medium	Small	Weighted average
Chemicals (excluding specialist pharmaceuticals) ..	1·86	1·31	0·90	1·72
Iron and steel ..	0·21	0·09	0·00	0·20
Non-ferrous metals ..	0·94	0·27	0·16	0·73
Engineering ..	0·49	0·29	0·32	0·41
Machine tools ..	0·46	0·42	0·00	0·37
Instruments ..	1·28	0·60	0·55	1·01
Boilers and structural	0·63	0·32	0·04	0·39
Electrical engineering	1·46	1·11	1·37	1·42
Specialist electronics	1·97	3·78	3·36	2·09
Shipbuilding ..	0·25	0·09	0·16	0·19
Vehicles	0·28	0·23	0·17	0·28
Other metal goods ..	0·33	0·22	0·00	0·22

Interdependence

Another factor affecting the overall efficiency of research on the national scale is the interdependence of various industries. In chemicals, metals, engineering, vehicles, food and drink, textiles, paper, glass, building materials and shipbuilding, the majority of respondents to the survey said that they were either considerably or moderately dependent on the work of other industries.

The case was put clearly by a large motor manufacturer, who said: "Research in many other industries will ultimately result in improved materials or equipment which will be found attractive for use in the motor industry, either for production or incorporation in the car. The rate of development in the motor industry is largely conditioned by that in other industries, and the lack of continuous output of materials and equipment will restrict this development."

The closer one looks at the relationships between different industries, the greater becomes the realisation of their interdependence. It soon becomes obvious that the only way to ensure optimum use of the available effort throughout industry as a whole is through some sort of national guidance. In some respects, of course, these matters take care of themselves through the natural law of supply and demand. But since the effects of research and development do not occur simultaneously with the currently reigning supply-and-demand law, there is an obvious case for long-range planning on a national scale.

Whether or not this is already being done satisfactorily through national bodies such as the DSIR and the FBI is largely a matter for speculation. However, the FBI survey itself gives us a clue to this question. In the first place, the excellent planning and execution of the survey indicate an enlightened understanding of the importance of getting to grips with the problems of research and development on an all-industries scale. But, at the same time, the results of the survey give an indication that there is still plenty of scope for fresh thinking and increased effort.

This Research Report has dealt with only a few of the questions and answers that arise from the joint FBI/NIESR survey. There are many others which make the survey (price 40*s* from the the F.B.I. at 21 Tothill Street London S.W.1) well worth studying.

Ubiquitous Transistors

A MINOR revolution of the radio industry was caused by the introduction of the transistor a few years ago. That revolution is still under way and radio sets are appearing in all sorts of forms and shapes. The low power consumption of the transistor has made the battery set a best seller once again and the small size has facilitated the " personal " portable. The same two factors have also made possible a big advance in the development of hearing aids.

Sets now on the market offer high-class reproduction with small consumption and light weight. The low consumption enables smaller batteries to be used while still giving reasonable life and it is this reduction that has the largest effect on the weight saving. Ordinary sets weigh in the region of 3 to 4 lb while the miniature personal sets (their quality reflects the small size of the speaker) weigh only about 1 lb. Much of the development has been in Japan, and there it is possible to purchase a fully transistorized portable television set for about £90.

One example of how the transistor set can be built into unlikely items is the pair of binoculars shown in the first illustration. These are a product of the Tokyo Transistor Industry Company Limited and are distributed by the Candle Trading Company Limited, 956, 3-chome, Nishi-Sugamo, Toshima-ku, Tokyo, Japan. The binoculars are aimed at sports goers who, with their aid, can both watch the progress of the game (or race) and hear the commentary from the official stand.

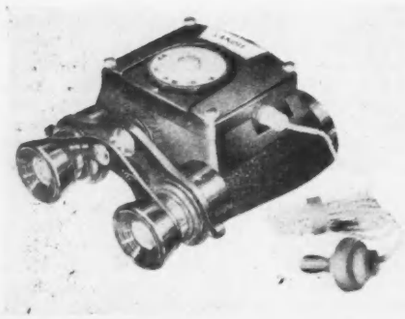
The binoculars give a magnification of 4 and have 35 mm centres. The lenses are optically ground. The whole assembly fits in a cube of 4½ in side. Two models of the radio are available, one with two and the other with three transistors. Both use a 9V battery. Reproduction is through an earpiece that connects by a jack plug to a socket in the set. The combination is carried in a cowhide case with a shoulder strap containing the loop antenna. A separate wire antenna is also available for use in areas of poor reception. The weight without the battery is 12 oz. The 3-transistor model costs about 75*s*, c.i.f., London.

Another combination in which a transistor set has appeared is in the handle of an umbrella. The possibilities of enjoying the radio while waiting in the rain for a bus are pleasant to think of, but perhaps not to others in the queue.

The go-small tendency is also illustrated by the combination radio and record player shown in the lower illustration. This is a product of Max Braun, Russelheimer Strasse, Frankfurt (Main) 1, West Germany. It consists of one of their standard transistor radios, either the type T31 or T4, linked in an anodized aluminium carrying case to a miniature battery-driven player. The whole measures only 9¼ in by 6⅛ in by 2 in.

Both radio sets have 7 transistors, 5 AM circuits and a push-pull output stage giving an output of approximately 150 mW. The loudspeaker is 2¾ in diameter. Type T31 is for medium and long wave reception only and type T4 adds the short wave band as well. Batteries last for about 140 hours. Both sets have facilities for a headphone, pick-up and time switch.

The tone arm of the player is contained in the body of the case and uncovered by a sliding panel operated by a projecting knob. It therefore plays the underside of the record, a point to be remembered when putting the record on to play. The cases of the radio and the record player units are made in polystyrene and the combination received the supreme award at the last Interplas exhibition for the best designed plastics consumer product.



(Left) With the Candle binoculars, sports goers can both watch progress and hear the official commentary.

(Below) A transistor radio and a record player are combined in the Braun unit which measures only 9¼ in by 6⅛ in by 2 in.

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